



**Response to Athabasca Chipewyan First Nation
Technical Information Request of Shell Pierre
River Mine Project**

From:
Shell Canada

May 2011

1.1 EIA Methodology

1. Athabasca Chipewyan First Nation's TK and TLU not used.

Request:

- i. Reassess the impacts of the proposed project using a pre-industrial baseline and fully integrating available TK and TLU information, including the updated Traditional Use Study Shell agreed to release by September 2010 (see Section 4.11.2 of this report).**

Response:

- i. An explanation of why Shell is not doing a pre-industrial assessment case is found in the Introduction to the JPME Technical Review Response document.

At the time of writing, the results of the Athabasca Chipewyan First Nation TLU study for the Project has not been made available. When the study becomes available, the information will be reviewed

Request:

- ii. Clearly identify all instances where TK and TLU changes the outcome of environmental consequence ratings.**

Response:

- ii. Available TK and TLU information was integrated into the EIA (2007) as listed below:
 - Consumptive use of plants: Terrestrial Vegetation, Wetlands and Forest Resources (Volume 5, Section 7.3.3), and Human Health (Volume 3, Section 5.3);
 - Medicinal use of plants: Terrestrial Vegetation, Wetlands and Forest Resources (Volume 5, Section 7.3.3), and Human Health (Volume 3, Section 5.3);
 - Spiritual use of plants: Terrestrial Vegetation, Wetlands and Forest Resources (Volume 5, Section 7.3.3), and Socio-Economics (Volume 5, Section 8.7);
 - Contamination of traditionally used plants: Air Quality (Volume 3, Section 3.3), and Human Health (Volume 3, Section 5.3);
 - Wildlife and wildlife habitat: Wildlife and Wildlife Habitat (Volume 5, Section 7.3.4);

- Consumptive use of wildlife (hunting and trapping): Wildlife and Wildlife Habitat (Volume 5, Section 7.3.4).
- Surface Water Hydrology: (Table 6.4-6; Volume 4, Section 6.4.4).
- Surface Water Quality: (Table 6.5-3; Volume 4, Section 6.5.4).
- Fish and Fish Habitat (Volume 4, Section 6.7.4).
- Traditional Land Use Assessment (Volume 5, Section 8.3)

TK and TLU information was considered in the determination of the environmental consequence ratings.

In 2008, ACFN provided additional TLU and TK in their report, *Athabasca Chipewyan First Nation Traditional Environmental Knowledge and Traditional Land Use Study for the Proposed Shell Jackpine Mine Expansion & Pierre River Mine Project* (Lepine 2008). This report was reviewed by Shell to identify information that might result in a change to the EIA findings. While new information was provided, the review indicated that the EIA findings and the linkages used in the assessment were still appropriate.

In 2009, Shell updated the EIA to consider incremental terrestrial effects to the project with the addition of a proposed Kears Lake levee (Section 2.4.2, Shell Jackpine Mine Expansion and Pierre River Mine Project EIA Update, December 2009). TK and TLU information in the area of the proposed levee alignment was considered for this Update. While the proposed levee added incremental terrestrial disturbance in close proximity to Kears Lake, it did not result in changes to the findings within the EIA.

Request:

- iii. Incorporate TK and TLU into the development of mitigation strategies, and identify all instances this changes the mitigation or the approach.**

Response:

- iii. Available TK and TLU information was considered in the mitigation strategies and EIA approach. For example, as a result of information provided by a directly-affected ACFN trapper (Registered Fur Management Area [RFMA] #1714), Shell included a commitment to facilitate access across the Project area to the trapline. Shell also committed to providing compensation to trappers directly affected by the Project in accordance with industry standards negotiated with First Nations.

Discussions with our key project stakeholders, including ACFN, have also recently resulted in the project including an option to divert the Muskeg River around the proposed development area in a channel instead of conveying its flows for a number of years in a water pipeline.

2. Impact description criteria do not consider confidence in the final impact rating.

Request:

Provide confidence ratings in the final impact ratings, including in the summary table (Table 1.3-4)

Response:

The Jackpine Mine Expansion (JME) and Pierre River Mine (PRM) Environmental Impact Assessment (EIA) used environmental consequence ratings to characterize impacts of the proposed projects. Typically, when using environmental consequence ratings, the final impact ratings are not given a formal confidence rating. However, confidence ratings are inherently provided in the predictions for all environmental components because all data, models and analytical methods used in the EIA are conservative and assume a worst case scenario. In addition, environmental components assessed in the JME and PRM EIA provided a discussion on the confidence of their conclusions that was based upon modelling results and compliance with existing guidelines. For example, water resources conducted an uncertainty analyses indicating that water quality predictions are robust, and confidence in their overall predictions for aquatic health is high.

The following principles were used in the JME and PRM EIAs to provide confidence in impact predictions:

- Conclusions were conservatively made and assumed that an effect was more rather than less adverse.
 - A record or audit trail of all assumptions, data gaps and confidence in data quality and analysis were provided to justify conclusions.
 - Mitigation measures were recommended to reduce adverse effects, followed by evaluation and management of effects and monitoring, to ensure effectiveness of these measures.
 - Mechanisms to evaluate monitoring results and provide for subsequent mitigation or project modification were implemented, as necessary.
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3. Pre-industrial baselines not included.

Request:

- i. Repeat key assessments within the EIA based on a pre-industrial baseline, incorporating the latest TLU information.**

Response:

- i. Please see Section 1.0 of the JME Technical Review response document for a discussion on why a pre-industrial baseline was not used.

Request:

- ii. Update the PDC against the pre-industrial baseline, using currently available project data**

Response:

- ii. Please see Section 1.0 of the JME Technical Review response document for a discussion on why a pre-industrial baseline was not used.

Request:

- iii. Provide documentation that Shell has obtained the ACFN's verification of Shell's interpretation of the ACFN's data.**

Response:

- iii. A summary of the ACFN TK/TLU information collected for the Jackpine Mine Expansion and Pierre River Mine projects is provided in Sections 3.3.3 and 3.4.3 of the *Traditional Land Use Environmental Setting for the Jackpine Mine Expansion & Pierre River Mine Project* report (December 2007). This information was collected from publicly available sources and used prior to the execution of a TK Sharing Agreement between ACFN and Shell.

Should ACFN provide any additional TK/TLU related to the JME and PRM projects, Shell will use it per the TK Sharing agreement, which contemplates in Section 5.2, the reasonable opportunity for the IRC to "review and verify the accuracy and appropriateness of the information related to TK, including the interpretation and analysis of TK."

4. Regional Study Area too large.

Request:

- i. Document the purpose and process for the sizing of an RSA, and explain how area-based key indicator resources (KIRs) could be significant in the RSA.

Response:

- i. The Regional Study Area (RSA) is used to evaluate the impacts of the Project in terms of larger geographic and ecological contexts. Spatial boundaries should extend beyond a project's immediate site to include the area likely to be affected.

A Reference Guide for the Canadian Environmental Assessment Act: Addressing Cumulative Environmental Effects (FEARO 1994) sets forth the following criteria for establishing spatial boundaries.

Ultimately, the RSA boundaries are project-specific, and Golder (2007) used conservative assumptions and professional judgment to set appropriate RSA boundaries for a methodically sound and scientifically defensible environmental assessment.

Golder (2007) used the FEARO (1994) criteria and available data to set the 2,277,376 ha Terrestrial Resources RSA boundary based on the following considerations:

- Use of suggested furthest potential measurable effect in combination with approved and planned projects in the region. The RSA was defined to encompass the 0.25 keq H⁺/ha/yr isopleth domain developed for the Jackpine Mine – Phase 1 Planned Development Case (PDC) scenario with consideration for extensions resulting from additional projects in the Project PDC.
- Inclusion of the community of Fort McMurray and other areas likely for future community expansions.
- Geographic and ecological areas, such as the eastern shoulder of the Birch Mountains.
- Natural region, subregion and/or vegetation classification boundaries.
- Allowances for the major river systems (e.g., Athabasca and Clearwater rivers) to act as natural study boundaries.
- A minimum of two moose home ranges from the centre of the majority of developments (about 26 km).
- Defined woodland caribou habitat areas (e.g., Audet, Firebag and Steepbank caribou areas).

If the boundaries are small, an understanding of the broad context may be sacrificed and important regional and long term effects, including effects on key indicator

resources, may not be examined (CEAA 1999). Pollutant transport by waterways, movements of far-ranging wildlife, and the progressive incursion of humans into hinterland areas are all reasons for assessment over larger geographic areas (CEAA 1999).

The effects on Key Indicator Resources (KIRs) can be significant within large RSAs. Environmental context may increase the environmental significance of an effect beyond that predicted by the magnitude of the measurable change if the affected indicator is rare or threatened, if a threshold is exceeded or a land use objective is contravened (CEAA 1999). Effects can also be significant if ecological thresholds or thresholds set by regional plans are surpassed (CEAA 1999).

References:

CEAA (Canadian Environmental Assessment Agency). 1999. *Cumulative effects assessment practitioners guide*. Prepared by the Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 134pp. Available online at: http://www.ceaa.gc.ca/43952694-0363-4B1E-B2B3-47365FAF1ED7/Cumulative_Effects_Assessment_Practitioners_Guide.pdf

FEARO (Federal Environmental Assessment Review Office). 1994. *The Responsible Authority's Guide to the Canadian Environmental Assessment Act*.

Golder. 2007. *Terrestrial Environmental Setting Report for the Jackpine Expansion and Pierre River Mining Areas Project*. Prepared for Shell Canada Energy. Calgary, AB. Submitted December 2007.

Hegmann, G., C. Cocklin, R. Creasey, S. Dupuis, A. Kennedy, L. Kingsley, W. Ross, H. Spaling, D. Stalker and AXYS Environmental Consulting Ltd. 1999. *Cumulative Effects Assessment Practitioners Guide*. Prepared by AXYS Environmental Consulting Ltd. and The Working Group for the Canadian Environmental Assessment Agency. Hull, PQ.

Request:

- ii. **Reassess the impacts on wildlife using LSAs and RSAs appropriate for each species.**

Response:

- ii. The Terrestrial Resources Local Study Areas (LSAs) and RSA were developed in accordance with guidelines set forth by the CEAA (1999) and the FEARO (1994), as outlined in the response to question 4i. All terrestrial components (i.e., soils and terrain, terrestrial vegetation, wetlands and forest resources, wildlife and wildlife habitat and biodiversity) were taken in to consideration in the design of the LSAs and

RSA. Therefore, appropriate LSAs and RSA were used for all Terrestrial Resources components.

Ultimately, the LSA boundaries are project specific, and Shell (see EIA, Volume 5; Shell 2007) used conservative assumptions and professional judgment to set appropriate LSA and RSA boundaries for a methodically sound and scientifically defensible environmental assessment.

References:

CEAA (Canadian Environmental Assessment Agency). 1999. *Cumulative Effects Assessment Practitioners Guide*. Prepared by the Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 134pp. Available online at: http://www.ceaa.gc.ca/43952694-0363-4B1E-B2B3-47365FAF1ED7/Cumulative_Effects_Assessment_Practitioners_Guide.pdf

FEARO (Federal Environmental Assessment Review Office). 1994. *The Responsible Authority's Guide to the Canadian Environmental Assessment Act*.

Shell (Shell Canada Limited). 2007. *Jackpine Mine Expansion & Pierre River Mine Project Application and Environmental Impact Assessment*. Volumes 1, 2, 3, 4 and 5. Submitted to Alberta Energy and Utilities Board and Alberta Environment, Calgary, Alberta. December 2007.

5. Assumptions that reclamation will be successful are unsupported.

Request:

- i. Identify what timeframe is considered to be 'far future' for full reversibility of impacts of the project.**

Response:

- i. For the purposes of this conceptual plan and to assess impacts related to the Project, 'far future' is defined as 80 years following the completion of reclamation activities (i.e., landscape recontouring, soil placement and planting).

Request:

- ii. Explain why ecosite phases are used in the assessment calculations and wildlife models even though Shell admits that it is not possible to predict the final community type.**

Response:

- ii. The reclamation target ecosite phases used in the assessment are aligned with Shell's objectives to establish a range of plant species with diversity levels that are analogous to natural areas. Planting prescriptions, identified in the Conservation, Closure and Reclamation (C, C&R) Plan in the EIA, provide targets on a regional scale, and the site conditions that are required for revegetation success (i.e., reclamation material, slope, moisture, aspect).

The planting prescriptions are an assessment tool used to compare pre-development ecosites to post-reclamation plant communities. The reclaimed landscape is expected to evolve and exhibit successional patterns similar to natural ecosite phases, depending on slope, aspect, moisture, and nutrient regimes. These reclamation projections are realistic based on current on-going research in the Oil Sands Region and are consistent with revegetation guidelines provided by the Cumulative Environmental Management Association (CEMA) (OSVRC 1998). These targets are widely accepted as an industry and regulatory standard to perform comprehensive assessments on terrestrial impacts of oil sands mining projects.

References:

OSVRC (Oil Sands Vegetation Reclamation Committee). 1998. Guidelines for Reclamation of Terrestrial Vegetation in the Oil Sands Region. 48 pp + Appendices.

Request:

- iii. **If Shell maintains that ecosite phases will be restored (including the dominant forbs), then provide specific targets (number of species, species composition, cover etc.) for each ecosite phase/wetland type to monitor and evaluate reclamation success.**

Response:

- iii. Shell does not maintain that restoration of pre-disturbance ecosite phases implies reclamation success. Shell's objective for the post-mining landscape is to establish a range of functioning ecosites capable of successional processes, with diversity levels that are analogous to locally-common natural areas in the boreal forest.

Shell will reclaim to comply with Reclamation Criteria for the Oil Sands Region when those parameters have been established, and using the most current guidelines as required for all oil sands mine disturbance areas. The draft Reclamation Certification Framework developed by the Cumulative Environmental Management Association (CEMA), currently under review, will determine similarity coefficients for assessment of reclamation success. These regulatory certification guidelines will specify the required targets at the landscape level and the re-establishment guidelines will be

followed as required during monitoring and management for the reclamation certification process.

Request:

- iv. If Shell admits that ecosite phases will not be restored, then re-analyze the data using “ecosite analogues” or some other category that indicates the lack of similarity and unpredictability of the final landscape.**

Response:

- iv. As noted in the response to Question 05iii, Shell does not maintain that restoration of pre-disturbance ecosite phases implies reclamation success. Shell’s objective for the post-mining landscape is to establish a range of functioning ecosites capable of successional processes, with diversity levels that are analogous to locally-common natural ecosite phases in the boreal forest.

Based on the requirements provided in current regulatory approvals, the goal of reclamation is not to restore pre-disturbance conditions, but to re-establish landscapes to an “equivalent capability”. Land capability is currently measured by the parameters outlined in the Land Capability Classification System (CEMA 2006), and the analysis carried out in the EIA shows that equivalent land capability will be achieved on the closure landscape (Appendix II, Shell 2008). This approach has been widely accepted as an industry and regulatory standard to perform comprehensive assessments on terrestrial impacts of oil sands mining projects.

Shell will establish reference sites (i.e., pre-disturbance and benchmark sites) and will monitor and manage slope, aspect and moisture regime to ensure that land capability for the project is equivalent to that which was present in pre-disturbance conditions. Appropriate soil types will be placed to achieve target land capability classes, and plant species that do not ingress naturally will be planted or seeded. The appropriate species are expected to thrive once suitable conditions have been established.

References:

CEMA (Cumulative Environmental Management Association). 2006. *Land Capability Classification System for Forest Ecosystems in the Oil Sands, 3rd Edition. Volume 1: Field Manual for Land Capability Determination*. Prepared for Alberta Environment by the Cumulative Environmental Management Association. Alberta Environment. 2006. Edmonton, AB. 148 pp.

Shell (Shell Canada Limited). 2008. *Application for Approval of the Jackpine Mine Expansion & Pierre River Mine Project Environmental Impact Assessment Update*. Submitted to the Energy Resources Conservation Board and Alberta Environment. May 2008.

Request:

- v. **Explain how Shell overcomes the fact that the approval of end pit lakes has been subject to test and, as yet, no such test has been successfully completed.**

Response:

- v. Shell is continuing to participate in industry efforts through CEMA and CONRAD to demonstrate pit lake performance. Field trials are now underway at Syncrude's Base Mine Lake and Shell anticipates that these trials will increase industry's understanding of pit lake dynamics. Beyond these studies, the recently formed Oil Sands Tailings Coalition now provides a mechanism to more openly share information related to tailings management. Working with industry, Shell will build on these efforts, as required, to demonstrate effective pit lake performance.

Request:

- vi. **Explain how Shell plans to incorporate the objective expressed in the ERCB Directive 074 (to minimize and eventually eliminate long-term storage of fluid tailings in the reclamation landscape) with this application.**

Response:

- vi. The ERCB approved Shell's Directive 074 plans for the Muskeg River Mine and Jackpine Mine – Phase 1 in September 2010 and December 2010, respectively. Now that Shell has approved Directive 074 plans for its base operations, the current focus is on expanding the plans to consideration of technologies that address the fate of fluid tailings in the closure landscape (such as Atmospheric Fines Drying, centrifugation and other methods) and these are being worked on for all mine areas including the Jackpine Mine Expansion and Pierre River Mine. Shell is supportive of Directive 074's focus on minimizing and eventually eliminating long-term storage of fluid tailings. These plans will describe how Shell plans to incorporate the ERCB objective into its proposed projects.

6. Long-term monitoring and mitigation not fully addressed.

Request:

- i. Address long-term monitoring and mitigation of impacts that may take years, even decades, to be detected.**

Response:

- i. Shell has included preliminary monitoring plans in Appendices 4-9 (Aquatics Monitoring Program) and 5-6 (Terrestrial Monitoring Programs). These preliminary monitoring plans have been developed to measure the short and long-term effects of the Project and to confirm that mitigation systems are effective and to provide detection of potential impacts to the environment. Pre-Project monitoring as part of the environmental setting investigation has already been done, and additional monitoring will be done during construction, operations, and at closure, as appropriate. Monitoring plans during the life of the project and after reclamation are conceptual at this time and will be developed after approval is granted for the Project.

In the unlikely event it is found that mitigation systems are not effective, adaptive management will be used to address potential issues. For example, Shell will adaptively control groundwater seepage by adding more wells or other mitigation, as required, to ensure that groundwater quality will be acceptable (PRM Round 1 ERCB SIR 319).

Request:

- ii. Provide preliminary monitoring plans or outlines of monitoring plans for each major environmental discipline (where not already provided in the application) for the PRM. Discuss Shell's commitment to provide the ACFN with the opportunity to review and make recommendations about these monitoring and research plans prior to a hearing.**

Response:

- ii. Shell has completed preliminary monitoring plans for the key environmental disciplines, namely Air Quality, Noise, Environmental Health, Aquatics and Terrestrial. ACFN was afforded the opportunity to review and make recommendations on some of these plans through the Technical Review process. The following discussion identifies where ACFN can find details on monitoring plans that Shell has already submitted to AENV and other appropriate regulatory bodies. The following also identifies where stakeholder involvement is included in the development of these plans.

Air Quality

The Project has been designed to minimize effects on air quality in the Oil Sands Region rather than monitoring the effects after they occur. Shell as committed to several operational standards to address this, please see Section 3.1.5.2, Volume 3 of

the EIA. Air quality management initiatives, including monitoring, assessment and mitigation of air emissions, are also found in Volume 3, 3.2.2.1 and 3.2.2.2, Section 3 of the EIA (Shell 2007). Some of the monitoring plans described in these sections include:

- Undertaking stack surveys and sampling on new boilers and heaters, consistent with Shell current EPEA Approval conditions;
- Expanding the existing Leak Detection and Repair Program to detect, measure and control emissions from equipment leaks from new facilities as per the Canadian Association of Petroleum Producers (CAPP) Management of Fugitive Emissions at Upstream Oil and Gas Facilities (CAPP 2007);
- Continuing to monitor volatile organic compounds (VOCs) through grab samples at ambient trailers per Wood Buffalo Environmental Association (WBEA) requirements; and
- Continuing to conduct fugitive emission surveys on the External Tailing Disposal Area (ETDA) and mine surfaces on site and at ambient trailers to quantify and speciate VOCs and total reduced sulphur (TRS) compounds by source.

Air emission effects mitigation measures are summarized in Volume 3, Section 3.2 of the EIA (Shell 2007).

Noise

Noise mitigation measures can be found in Volume 3, Section 4.1.2, of the EIA (Shell 2007). During detailed design stages of the Project, a noise management plan will only be developed for the Pierre River Mine Project, as there are no predicted exceedances of the permissible sound levels at the Jackpine Mine Expansion (see EIA, Volume 3, Section 4.6.3.2). The noise management plan will follow the requirements under Section 5.1 of ERCB Directive 038 and will incorporate commitments made in the EIA, an updated Noise Impact Assessment, a monitoring program design and ERCB requirements for stakeholder involvement in the plan development (PRM Round 1 ERCB SIR 253a).

Environmental Health

Shell supports many regional programs aimed at addressing human health issues in the Oil Sands Region, including:

- the Regional Aquatics Monitoring Program (RAMP);
- the Cumulative Environmental Management Association's (CEMA) End Pit Lake task group;
- cooperating with AENV and other regulatory bodies to in the identification of parameters to be used for assessing pit lakes and the potential effects on human health;
- assessing pit lakes to determine if aquatic health is considered to pose a threat to human health; and

- relevant air and water quality mitigation measures in Sections 3.2 and 6.5, respectively of Volume 3 (Shell 2007).

Aquatic Resources

The conceptual Aquatics Resources monitoring plan is presented in Appendix 4-9 of the EIA (Shell 2007). The proposed monitoring program will be based on the current monitoring for Jackpine Mine – Phase 1 and AENV, DFO and key stakeholders will review the program (PRM AENV Round 1 SIR 17a).

Monitoring plans for individual aquatic disciplines can also be found in the following locations:

- Groundwater: Section 6.1.2.4, Volume 4A (Shell 2007). The groundwater monitoring program will be implemented by Shell to monitor the effects of the Project due to depressurization of the Basal Aquifer and dewatering of the overburden materials, including the PCA. The monitoring program will also include monitoring the effects on overburden groundwater quality due to ETDA operations, pit backfilling, and plant facilities.
- Water Quality: Section 6.1.4.3, Volume 4A (Shell 2007). The preliminary water quality monitoring plan will be updated upon approval of the Project to satisfy regulatory requirements of AENV and DFO.
- Fish and Fish Habitat: Section 6.1.6.2, Volume 4A (Shell 2007). Monitoring will be conducted as part of Shell's adaptive management strategy to verify predicted effects and to confirm that the No Net Loss objective has been achieved. Final details of the habitat compensation plan, monitoring requirements and adaptive management strategies will be included in the detailed NNLP to be developed in consultation with the appropriate regulatory agencies and stakeholder groups. Shell will also implement a comprehensive monitoring program for hydrology, water quality and fish and fish habitat. This program may include the assessment of streamflows, water levels and discharge rates, channel stability and morphology, water and sediment quality, littoral zone development, growth of aquatic vegetation, benthic invertebrate communities, fish populations and riparian zone vegetation (Shell 2007).

Shell will also develop a wetland monitoring program for areas adjacent to the Project, to determine the effects of surficial aquifer drawdown (PRM Round 1 AENV SIR 378a).

Terrestrial Resources

The conceptual Terrestrial Monitoring Plans are presented in Appendix 5-6 of the EIA. The Terrestrial Monitoring Plan includes details on the. Monitoring and mitigation plans for all terrestrial disciplines are summarized in Section 7.1.3, Volume 5 of the EIA (Shell 2007). As with most monitoring plans, all Terrestrial Monitoring Plan outlined in Appendix 5-6 will be prepared in consultation with ASRD, AENV, forestry rights holders and other appropriate regulatory bodies and key stakeholders. Shell will

also design a wetlands monitoring program for areas adjacent to the Project to determine the effects of surficial aquifer drawdown.

Human Environment

The Project has been designed to mitigate potential effects of the Project on Human Environment components (see EIA, Volume 5, Section 8.2.6.5). The primary mitigation associated with many of those effects is reclamation and closure, as detailed in Volume 4, Appendix 4-3 and 4-4.

References:

CAPP (Canadian Association of Petroleum Producers). Best Management Practice. Management of Fugitive Emissions at Upstream Oil and Gas Facilities. 2007.

Shell (Shell Canada Limited). 2007. *Jackpine Mine Expansion & Pierre River Mine Project Application and Environmental Impact Assessment*. Volumes 1, 2, 3, 4 and 5. Submitted to Alberta Energy and Utilities Board and Alberta Environment, Calgary, Alberta. December 2007.

7. Environmental consequences ratings for high magnitude impact unclear.

Request:

Explain why Shell has chosen 20% as the cutoff for high magnitude impacts for many parameters, including the scientific basis for this number. Provide peer reviewed references, documentation that the ACFN have had these peer-reviewed references provided to them, and that the ACFN have verified this assessment criterion.

Response:

- i. For terrestrial resources, the magnitude of effects was categorized according to the following criteria (EIA, Volume 3, Section 1.3.6.1):
 - negligible (0): <1% change on the measurement end point;
 - low (+5): <10% change in measurement end point;
 - moderate (+10): 10 to 20% change in measurement end point; and
 - high (+15): >20% change in measurement end point.

These categories and criteria were assigned using professional judgement to create a classification scheme that is transparent and can be consistently applied. The same categorization and scoring for the magnitude of environmental effects was applied in a

recent independent assessment of the effects of the Project (Fort McKay IRC 2009). In addition, a similar classification was used for classifying the magnitude of effects in the Terrestrial Ecosystem Management Framework (TEMF) for the Regional Municipality of Wood Buffalo. In the TEMF, declines of <10%, 10 to 20%, and >20% below the natural range of variation were classified as green, yellow and red condition, respectively (CEMA SEWG 2008). Classifying changes to an indicator that exceed 20% as 'high' magnitude represents a conservative estimate of the magnitude of an environmental effect. The use of 20% as a threshold for high impacts is supported by the Canadian Environmental Assessment Act (CEAA 2010, online) Operational Policy Framework for Adaptive Management Measures which suggests that when accepted science-based thresholds for terrestrial resources do not exist, a 20% effect level can be used.

Swift and Hannon (2010) provide a review of the applicability of critical thresholds associated with habitat loss. Thresholds associated with habitat loss have been examined through modelling. These models suggested thresholds at 29% to 50% remaining cover depending on the habitat arrangement. Others have observed thresholds at the lower end of this range (Andren 1994). Although empirical data are limited, these modelling results are supported by empirical studies (e.g., bay-breasted warblers)

It is important to note that the predicted environmental consequence (i.e., significance) of a change is determined using more than simply magnitude. In keeping with the guidelines set by the Canadian Environmental Assessment Agency (FEARO 1994), environmental significance was determined by taking into consideration magnitude, geographic extent, duration, reversibility, frequency and environmental context (refer to the EIA, Volume 3, Section 1.3.6.2; Shell 2007). Environmental context was incorporated using professional judgement to predict the overall environmental consequence (refer to the EIA Volume 5, Section 7.2.6.4; Shell 2007). For example, environmental context may increase the environmental significance of an effect beyond that predicted by the magnitude of the measurable change if the affected indicator is rare or threatened, if an ecological threshold is exceeded, or if thresholds set out in regulations and guidelines are exceeded (CEAA 1999).

References:

- Andren, H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. *Oikos* 71:355–366.
- CEAA (Canadian Environmental Assessment Agency). 1999. *Cumulative effects assessment practitioners guide*. Prepared by the Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd. 134pp. Available online at: http://www.ceaa.gc.ca/43952694-0363-4B1E-B2B3-47365FAF1ED7/Cumulative_Effects_Assessment_Practitioners_Guide.pdf

CEAA. 2010. Operational Policy Statement. Adaptive Management Measures under the Canadian Environmental Assessment Act. [Available Online: <http://www.ceaa.gc.ca/default.asp?lang=En&n=50139251-1>]

CEMA SEWG (Sustainable Ecosystem Working Group of the Cumulative Environmental Management Association). 2008. *Terrestrial ecosystem management framework for the Regional Municipality of Wood Buffalo*. 57 pp. Available online http://cemaonline.ca/component/docman/doc_download/1484-temf-framework-document.html Accessed on: February 3, 2011.

FEARO (Federal Environmental Assessment Review Office). 1994. *The Responsible Authority's Guide to the Canadian Environmental Assessment Act*.

Fort McKay IRC (Fort McKay Industry Relations Corporation). 2010. *Fort McKay Specific Assessment (Supplemental Information for the Shell Canada Limited Jackpine Expansion and Pierre River Mine Project)*. March 2010. p. 1,493.

Shell (Shell Canada Limited). 2007. *Jackpine Mine Expansion & Pierre River Mine Project Application and Environmental Impact Assessment*. Volumes 1, 2, 3, 4 and 5. Submitted to Alberta Energy and Utilities Board and Alberta Environment, Calgary, Alberta. December 2007.

Swift, T.L. and S.J Hannon, 2010. Critical thresholds associated with habitat loss: A review of the concepts, evidence and applications. *Biological Reviews* 85:35–53.

8. Environmental consequences ratings for reversible impacts unclear.

Request:

Explain, in biological terms, how a reversible impact could be a positive force, rather than a neutral force, including the scientific basis for these numbers. Provide peer-reviewed references, and documentation that the ACFN have had these peer-reviewed references provided to them and that the ACFN have verified these assessment criteria.

Response:

The residual impact criterion of ‘reversibility’ is a component of the environmental consequence rating, which estimates the environmental consequence of an impact (EIA, Volume 5, Section 1.3.6). The residual impact criterion of ‘direction’ indicates the assessed positive or negative influence of an impact, but is not a component of the environmental

consequence rating. Therefore, the score assigned to ‘reversibility’ in the environmental consequence rating cannot change a negative effect to a positive one. Reversibility is considered not applicable when the direction of the impact is positive, because it is expected that positive impacts would be retained after closure and reclamation.

The reversible nature of an impact is not a positive force. However, “reversible adverse environmental effects may be less significant than adverse effects that are irreversible” (FEARO 1994). For example, the loss of old growth forests in the LSAs is reversible because regenerated forests on reclaimed sites have the capacity to become old growth forests over time. The reversibility of this effect reduces the environmental consequence rating because reversibility generally reduces the environmental significance of the effect.

References:

FEARO (Federal Environmental Assessment Review Office). 1994. *Determining whether a project is likely to cause significant adverse environmental effects: a reference guide for the Canadian Environmental Assessment Act*. 16 pp. Available online: <http://www.ceaa.gc.ca/default.asp?lang=En&n=D213D286-1&offset=&toc=hide>

1.2 Groundwater

9. Impacts of ETDA on groundwater not assessed.

Request:

- i. Identify the impact of ETDA on the discharge of tailings liquids into groundwater.**

Response:

- i. The effects of ETDA seepage were assessed for the groundwater receptors, which are the surface water bodies in the area downgradient of the ETDA. The changes in groundwater quality due to ETDA seepage were quantified in the Hydrogeology section of the EIA, while the effects to surface water bodies, the groundwater receptors, were assessed in the Water Quality section of the EIA. This approach is in agreement with the source-pathway-receptor concept for the assessment of effects.

References:

Komex (WorleyParsons Komex). 2007. *Hydrogeology Environmental Setting Report for the Jackpine Mine Expansion & Pierre River Mine Project*. Prepared for Shell Canada Limited. Calgary, AB. Submitted December 2007.

Request:

- ii. Identify engineering methods available to reduce this discharge to zero.**

Response:

- ii. The various components of the ETDA seepage interception/containment system that will be active during the operational period include a perimeter ditch around the ETDA, a system of pumping wells in the PCA, a groundwater monitoring well network and a mitigation plan to address any observed ETDA groundwater seepage impacts. Where the PCA is not present, the bedrock surface along the ETDA perimeters is relatively shallow (generally less than 4 m deep), as a result the perimeter ditch can be reasonably expected to fully intercept ETDA seepage. Therefore, seepage that reaches the Quaternary deposits beneath the ETDA is expected to be fully captured.

During the post-closure period, seepage from the ETDA will be allowed to flow to treatment wetlands where it will be collected and treated passively. The reclaimed landscape will be contoured and backfilled such that during the post-operational period ETDA groundwater seepage is topographically driven northward from the ETDA towards the seepage treatment wetlands located adjacent to the north end-pit lake. Additional details of this post-closure ETDA seepage management are provided in the response to question 9iv.

Request:

- iii. Explain why reclamation of the ETDA would require 20 years or more after filling is complete.**

Response:

- iii. The ERCB approved Shell's Directive 074 plans for the Muskeg River Mine and Jackpine Mine – Phase 1 in September 2010 and December 2010, respectively. Now that Shell has approved Directive 074 plans for its base operations, the current focus is on expanding the plans to consideration of technologies that address the fate of fluid tailings in the closure landscape (such as Atmospheric Fines Drying, centrifugation and other methods) and these are being worked on for all mine areas including the Jackpine Mine Expansion and Pierre River Mine. Shell is supportive of Directive 074's focus on minimizing and eventually eliminating long-term storage of fluid tailings. These plans will describe how Shell plans to incorporate the ERCB objective into its proposed projects

Request:

- iv. Identify the time period estimates for full remediation of groundwater quality from ETDA seepages, and the basis for these estimates.**

Response:

- iv. Groundwater quality in the reclaimed landscape between the North ETDA and the North Pit Lake will be different than the pre-development quality of groundwater in the pre-mining shallow deposits. The reason is that the pit north of the North ETDA will be backfilled with overburden material (in-pit OBDA). The post-closure groundwater quality in this area will be the result of the ETDA seepage interactions with the overburden material and with recharge from precipitation. This groundwater will eventually discharge to the North Pit Lake.

As indicated in the response to question 9i, the effects of ETDA seepage were assessed for the groundwater receptors, i.e. the North Pit Lake. At closure (2065), 16 years after the end of mining, water quality modelling indicated that the water quality of the north pit lake would be acceptable for release to the Muskeg River (EIA, Volume 4A, Section 6.5.5.3, page 6-419).

10. Groundwater incident reporting to the ACFN unconfirmed.

Request:

- i. **Discuss how the ACFN would be advised of any groundwater incidents at the PRM that are reported to government agencies.**

Response:

- i. Shell is open to discussing this further with ACFN. Shell suggests that groundwater incidents reported to regulators be reviewed annually with ACFN. Where there is the potential to directly impact ACFN, Shell would inform the ACFN as soon as reasonably possible per our Good Neighbour Principles and in accordance with statutory and regulatory obligations / duties.

Request:

- ii. **Explain why Shell does not think that impacts on groundwater (and thus on present and future users of that groundwater) are not part of the ERCB's Public Interest Determination.**

Response:

- ii. As part of the ERCB's public interest determination, Shell has conducted a detailed assessment to aquatic resources, which includes consideration of groundwater impacts (see Section 6, Volume 4 – Dec. 2007, as amended).

11. Commitment to presenting groundwater monitoring data to the ACFN unclear.

Request:

- i. Commit to presenting groundwater monitoring data to the ACFN in a form that will gain the ACFN's confidence by demonstrating that the groundwater monitoring is accurate and responsive to potential impacts. This should include comparisons with data from Shell's existing operations.**

Response:

- i. Shell groundwater monitoring reports that are routinely provided to regulators are available publicly. Shell provides regional groundwater monitoring data to ACFN and includes groundwater data in its annual report. Shell is open to discussing how this information could be provided to ACFN in an alternative format.

Request:

- ii. Explain why Shell does not think that data on groundwater quantity and quality should not be held in the public domain when that resource is used (or may be used in the future) by Treaty and Aboriginal rights-bearing First Nations, including the ACFN.**

Response:

- ii. Shell agrees with ACFN that groundwater data from its operations should be in the public domain. Accordingly, Shell provides its groundwater data for existing operations to the regulators as prescribed and summarizes its findings in an annual report. This information is available to all interested parties, including ACFN, as requested. Shell will do likewise for the proposed projects, if approved.
-
-

12. Groundwater contamination transport within the region poorly understood.

Request:

- i. Assess the impact of solution transport of contaminated groundwater on surface water in the region using a 3-D solute transport model.**

Response:

- i. Cumulative effects assessment of groundwater quality is not needed because groundwater quality effects of individual oil sands projects do not overlap spatially to a significant degree and therefore local groundwater quality effects assessments as conducted for the EIA are adequate. Regional cumulative effects assessments of water quality are conducted at the point of aggregation, which is the surface water environment. Surface water quality assessments for the Base Case, Application Case and Cumulative Effects Case were discussed in EIA Volume 4a, Section 6.5.

This view is supported by the following:

- During operations, groundwater flow will be directed towards the mine pits. Mitigation measures will be implemented where required (e.g., PCA south of North ETDA) to prevent off site seepage of process-affected water.
- After closure, groundwater flow within the mine footprint will be directed toward the end-pit lakes. Dykes or low permeability barriers will be in place, where required, to prevent seepage of process water into the Quaternary deposits. For more information please see PRM Round 1 SIR 271a.
- After closure, process-affected water is predicted to reach the Basal aquifer at low rates. A 3D simulation of mass transport (using MT3D) in the Basal aquifer was conducted to assess the effects of the seepage. Results of the simulations were inputs for the assessment of changes to water quality of the Athabasca River. This assessment accounted for the potential inputs from the adjacent existing and proposed facilities. The surface water quality analysis indicated that effects to the Athabasca River were negligible.

Request:

- ii. **Discuss Shell's plans to monitor and verify the results of the local scale solute transport modelling.**

Response:

- ii. A groundwater monitoring program developed for the Project was presented in the EIA, Volume 4, Appendix 4-9. Specific information was provided on:
 - Analytical parameters for Groundwater Quality (Section 2.1.3; Table 1).
 - Groundwater Monitoring Schedule (Section 2.1.4; Table 2).
 - Reporting (Section 2.1.7).
 - Current Monitoring activities at JME and surrounding operations (Sections 2.2 and 2.3), including existing Basal Aquifer wells (Figure 1), Pleistocene Channel wells (Figure 2) and Quaternary wells (Figure 3).

The groundwater monitoring program for JME will incorporate, where possible, the existing monitoring wells installed as part of the environmental setting investigation. New groundwater monitoring wells will be installed in each proposed development area before mining activities begin to allow for sampling to establish baseline conditions at each monitoring location. The groundwater monitoring network will evolve throughout the life of the Project to adequately characterize the effects of the Project (EIA, Appendix 4-9, Section 2.3), including water quality. In this manner, the monitoring network that will be established for the Project will be used to verify the results of the local scale solute transport modelling conducted for the EIA by comparing model-predicted plume extents (Volume 4, Section 6.3.5) to monitored concentrations of key parameters.

Monitoring will also be implemented in the Basal aquifer, downgradient of the potential sources of process water (e.g., North ETDA).

Shell is also a participant in RAMP. Shell understands that RAMP effectiveness is being reviewed and supports improvements to the existing regional aquatic monitoring efforts, as required.

Should substantial, unexpected effects on groundwater levels or quality, relative to baseline conditions, be detected, an incident-specific groundwater response plan will be developed and implemented. In general, the response plan would include the following elements:

- conduct confirmatory sampling;
- notify Alberta Environment upon confirmation;
- assess monitoring frequency and adjust as required;
- identify the source(s);
- determine the magnitude and extent of effects;
- develop a remediation plan and/or risk management strategy, if necessary;
- isolate or remove the source, if possible;
- submit the remediation plan and/or risk management strategy to Alberta Environment for approval; and
- implement the remediation plan and/or risk management strategy.

Request:

- iii. Discuss Shell's commitment to regional groundwater modelling.**

Response:

- iii. Regional groundwater modelling is not needed because groundwater quality effects of individual oil sands projects do not overlap spatially to a substantial degree. With the implementation of the proposed mitigation measures, effects on the groundwater quality will be local and will be largely restricted to the reclaimed mine footprint.

Request:

- iv. **Discuss Shell's commitment to a timely and coordinated management response if issues are identified in the local or regional monitoring.**

Response:

- iv. The groundwater monitoring program will be in place within the project area to provide early detection of potential changes in groundwater quality (see EIA, Volume 4B, Appendix 4-9, Section 2). If changes are detected, a groundwater response and mitigation plan will be implemented to minimize the extent of the effects.

13. Access and use of traditional groundwater sources may be impacted.

Request:

Confirm that Shell has discussed the possible locations of groundwater sources used by ACFN members in a manner that ensures that ACFN members are aware that the water sources they use are in fact groundwater-dependent (e.g., fens) and may be affected by the project. Provide the documentation indicating both that this information exchange has occurred, and that the ACFN have verified this exchange.

Response:

Shell has conducted a detailed assessment of aquatic resources per Section 6, Volume 4 – Dec. 2007, as amended of the EIA. Shell funded a Technical Review of the EIA for the purposes of allowing ACFN to understand how predicted effects might impact the exercise of Aboriginal and Treaty Rights. The ACFN IRC was encouraged to involve Elders and community members in the Technical Review process to ensure that predicted effects, such as those to groundwater, would be considered in regard to potential impacts to the exercise of Aboriginal and Treaty Rights.

Shell also funded the collection of Traditional Land Use and Traditional Environmental Knowledge information. This information is critical to allowing Shell to better understand potential impacts to the exercise of Aboriginal and Treaty Rights. The information collected by ACFN in 2008 was not incorporated into the EIA since ACFN did not allow

its use. Shell funded the collection of supplementary TK/TLU however this information has not yet been received.

Per the executed TK Sharing agreement with ACFN, Shell personnel are not able to speak with or have contact with those involved during the collection of TLU/TK.

1.3 Surface Water Quality

14. List of modeled parameters unclear.

Request:

- i. Provide a list of those parameters (chemicals) that were not modelled due to unavailability.**

Response:

The following parameters were not modelled in the CNRL diversion channel because the data were not available from the CNRL EIA:

- monomer;
- labile naphthenic acids;
- refractory naphthenic acids;
- PAH groups 1 to 9;
- tainting potential;
- acute toxicity; and
- chronic toxicity

Given that these constituents were not modelled by CNRL, it is not possible for Shell to derive concentrations of these constituents in the CNRL diversion channel. Furthermore, given that Pierre River is not predicted to receive operational discharges from the project, the addition of the clean Pierre River to the CNRL Diversion Channel could only result in lower concentrations in the Application Case compared to the Base Case, so modelling these constituents would not yield useful information with respect to impact assessment.

Requests:

- ii. **Describe the methods, cost and time required to assess a full suite of metals and PAHs.**

Response:

See the response to question 14i.

15. Uncertainty analysis for LSA project impacts lacking.

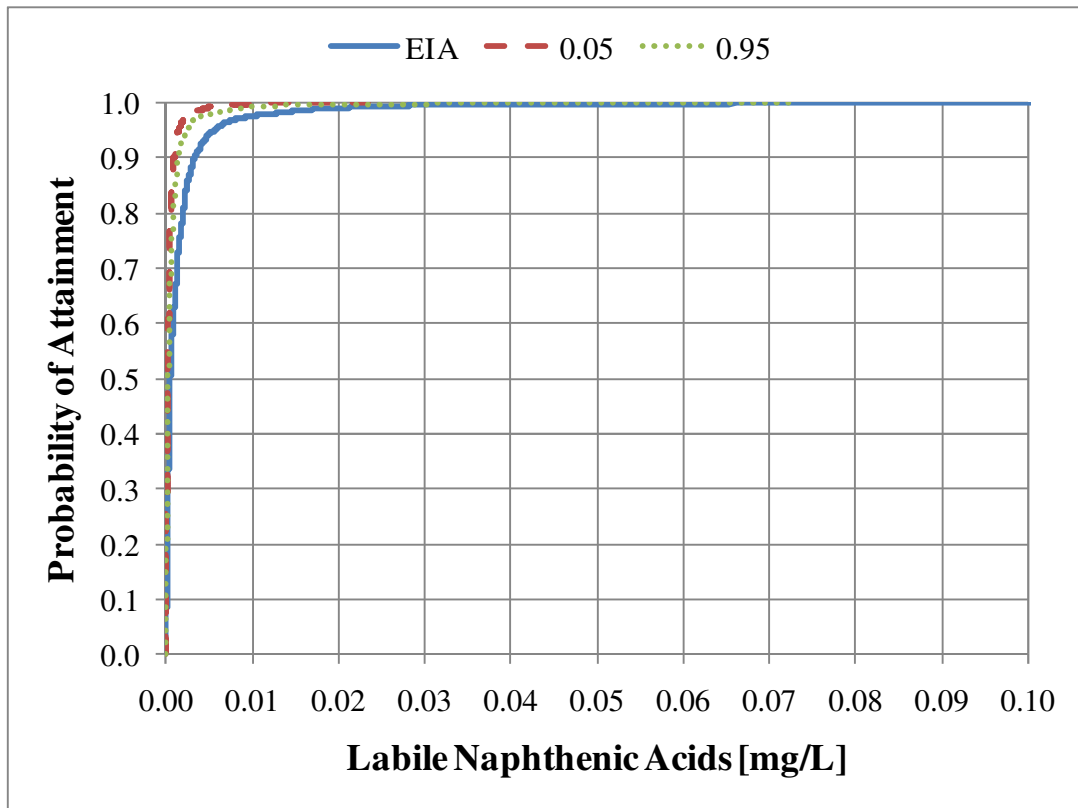
Requests:

Conduct a water quality uncertainty analysis that is specific for the LSA impacts of the PRM, and provide the results as part of the project application supplemental information.

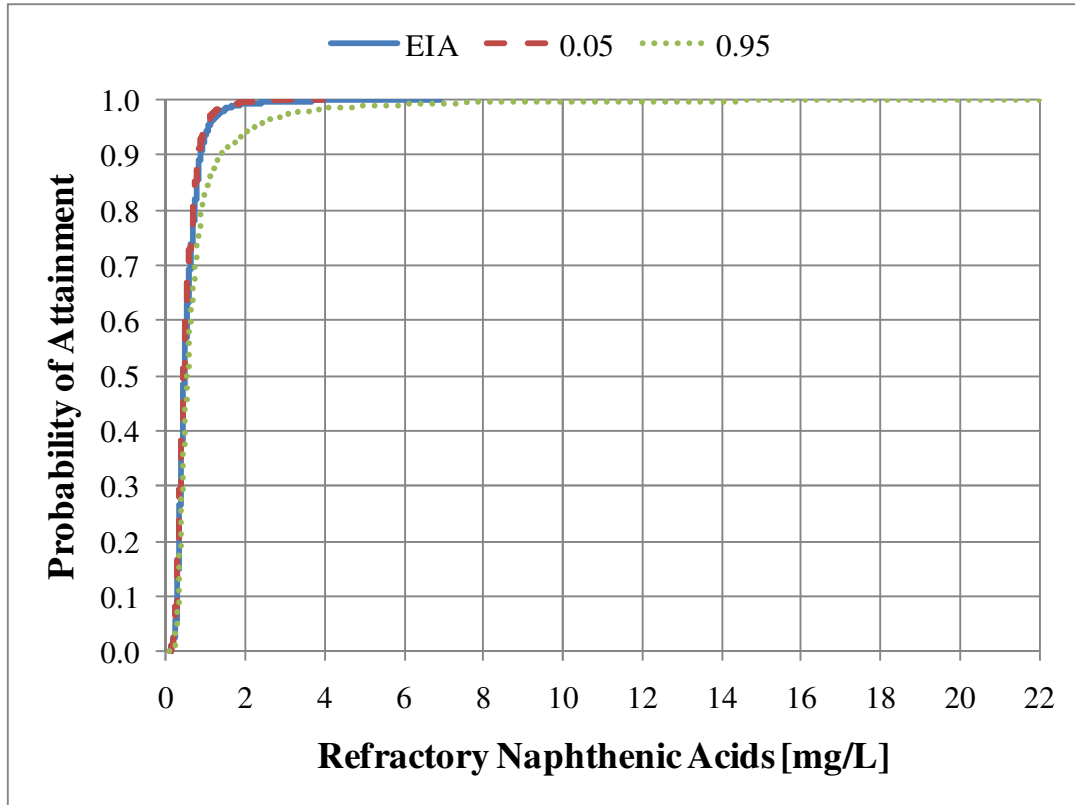
Response:

An uncertainty analysis for PRM was performed downstream of Pierre Pit Lake using the methods presented in EIA, Appendix 4-2, Section 2.1.5. The results are presented below:

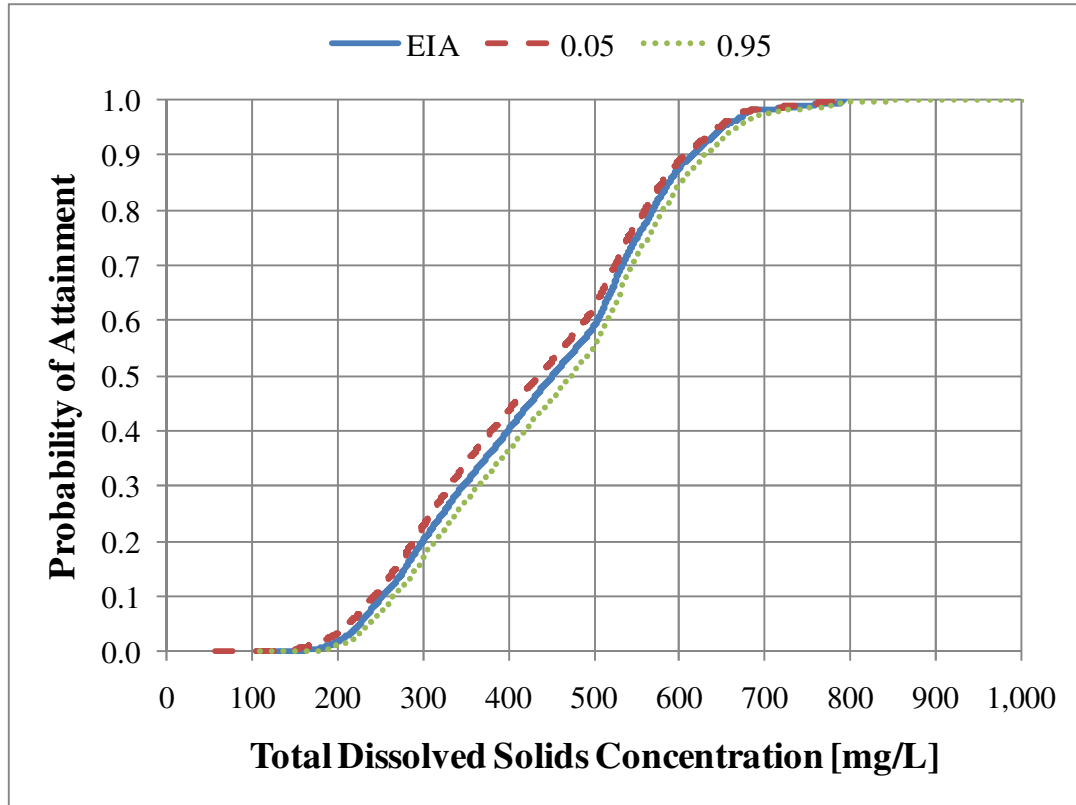
- a) Labile Naphthenic Acids



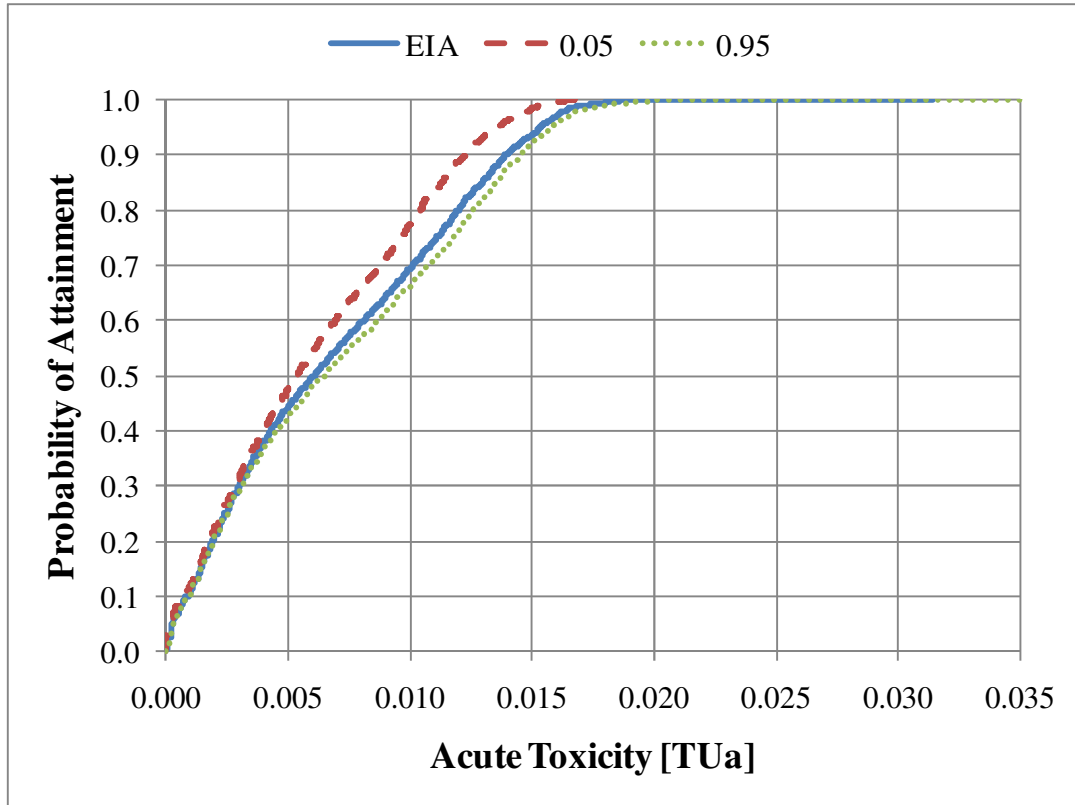
b) Refractory Naphthenic Acids



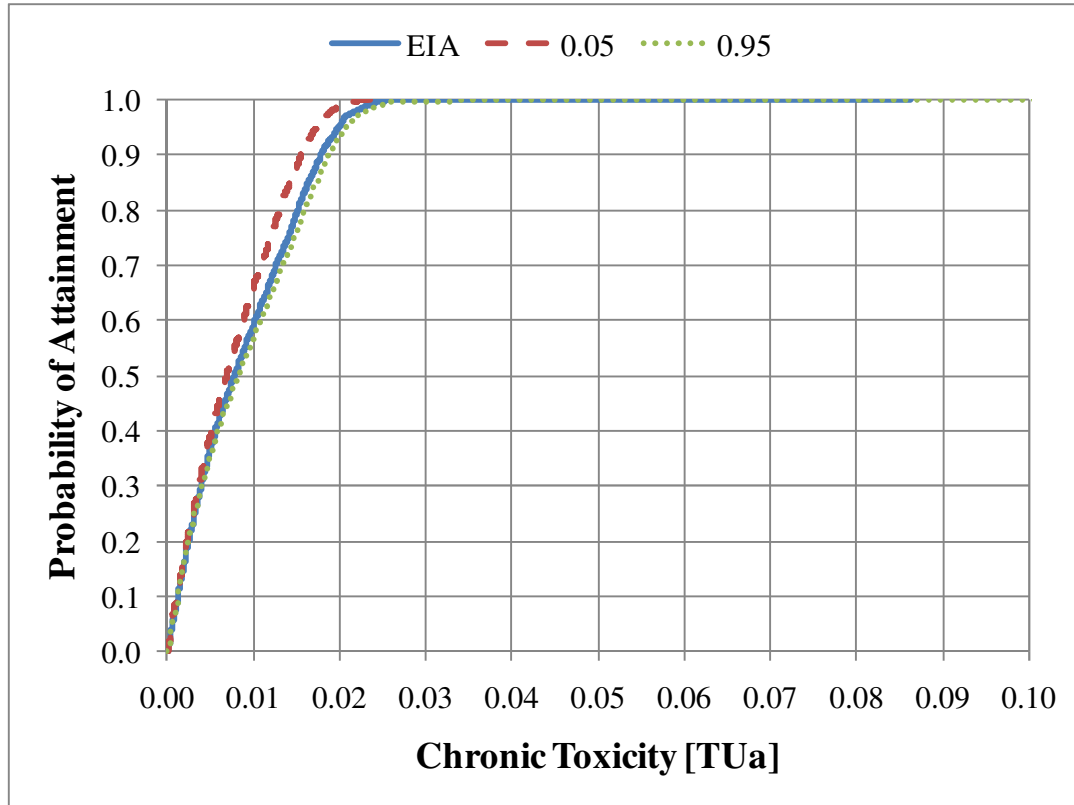
c) Total Dissolved Solids



d) Acute Toxicity



e) Chronic Toxicity



16. Regulatory guideline exceedances inappropriately used as impact thresholds.

Requests:

- i. Provide additional discussion on the impacts of absolute increases in a full suite of parameters with guidelines, irrespective of whether guideline exceedances occurred.**

Response:

To assess the impact on aquatic life due to changes in water quality, the most stringent guideline was adopted from Alberta Environment, the Canadian Council of Ministers of the Environment (CCME) and the U.S. Environmental Protection Agency (U.S. EPA) for each constituent.

As stated in the Canadian Environmental Quality Guidelines (CCME 1999), “Guidelines are numerical limits or narrative statements based on the most current, scientifically defensible toxicological data available for the parameter of interest. Guideline values are meant to protect all forms of aquatic life and all aspects of the aquatic life cycles, including the most sensitive life stage of the most sensitive species over the long term.” Guideline values are generally derived by determining, through toxicological testing, the lowest concentration that would result in no adverse effects on the health of aquatic organisms, then dividing the concentration by ten as a margin of safety. Therefore, guidelines are considered highly protective, and further assessment for constituents that are predicted to increase but remain below guideline values is not required.

References:

CCME (Canadian Council of Ministers of the Environment). 1999. *Canadian Environmental Quality Guidelines*. Canadian Council of Ministers of the Environment, Winnipeg.

Requests:

- ii. **Discuss the potential impacts and changes that could occur due to the predicted large increases in metals in Big Creek.**

Response:

Please see the aquatic health assessment that was conducted for Big Creek in the EIA, Volume 4A, Section 6.6.5.3.

Information in the water quality impact tables insufficient.

17. Request:

Provide the percentage change, as well as the absolute change, in the results tables for the water quality assessment to allow comparison with the ratings criteria.

Response:

The percentage and absolute change in concentrations are provided in Tables 16-1 to 16-10. As noted in EIA Volume 4A, Section 6.5.5.3, relative change in constituent concentrations is one of several lines of evidence used in the water quality and aquatic health assessments. On their own, these values are not indicative of effects to aquatic health.

Table 17-1 Percent and Absolute Change in Concentrations Predicted for M3 Under Application Case

	Percent Change from Pre-development										Percent Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	58%	-17%	108%	-3%	78%	-13%	483%	-25%	206%	-35%	-3%	-8%	25%	-4%	-51%	-2%	24%	0%	0%	-5%
ammonia	91%	-50%	109%	-50%	-20%	-55%	-61%	-50%	-57%	-41%	-24%	-21%	10%	-15%	-15%	8%	13%	38%	-24%	33%
antimony	0%	-21%	11%	-36%	0%	-45%	74%	-52%	78%	-40%	0%	0%	3%	-23%	-45%	-23%	-19%	-20%	-31%	-11%
arsenic	77%	148%	159%	122%	23%	-43%	150%	109%	91%	-39%	-20%	-20%	4%	-19%	-59%	-50%	-15%	-6%	-41%	-13%
barium	169%	-44%	169%	-40%	6%	-45%	38%	-37%	81%	-28%	-13%	-15%	0%	-13%	-47%	13%	-14%	40%	0%	44%
beryllium	-	-	-	-	-	-	-	-	-	-	0%	-17%	0%	0%	0%	20%	33%	0%	0%	-14%
boron	33%	-16%	59%	-8%	104%	-8%	1,267%	61%	696%	24%	-4%	-5%	3%	-5%	-58%	-8%	16%	6%	5%	7%
cadmium	1%	-31%	38%	-31%	84%	-38%	325%	-38%	268%	-31%	-12%	-14%	-8%	-18%	-53%	-16%	-23%	-6%	-33%	-5%
calcium	136%	35%	106%	18%	31%	9%	17%	-2%	28%	6%	-1%	-10%	6%	2%	-2%	18%	8%	37%	18%	38%
chloride	63%	-21%	70%	-10%	241%	34%	1,715%	197%	974%	131%	0%	-4%	-10%	-10%	-43%	3%	9%	-13%	-9%	-26%
chromium	150%	619%	186%	556%	43%	447%	150%	-33%	55%	-39%	-9%	-21%	4%	-14%	-33%	119%	11%	5%	-24%	8%
cobalt	205%	259%	330%	159%	55%	0%	265%	6%	105%	-29%	-23%	-30%	13%	-12%	-55%	-43%	0%	-5%	-23%	9%
copper	163%	32%	198%	140%	51%	24%	163%	-2%	75%	-18%	-12%	-15%	6%	-20%	-43%	-28%	7%	-16%	0%	-5%
dissolved organic carbon	11%	-20%	6%	-24%	-11%	-22%	22%	-15%	33%	-7%	-5%	-4%	0%	-9%	-20%	5%	0%	15%	9%	16%
iron	-17%	-42%	-23%	-37%	-23%	-10%	-43%	-63%	8%	-57%	0%	0%	-5%	-22%	3%	91%	-10%	16%	18%	17%
lead	40%	-18%	50%	-30%	-20%	-52%	40%	-61%	40%	-52%	0%	0%	0%	-4%	-57%	-20%	-18%	-19%	-45%	-20%
magnesium	64%	-24%	45%	-30%	9%	-30%	9%	-23%	18%	-13%	0%	-4%	7%	-9%	0%	14%	0%	34%	8%	41%
manganese	131%	-35%	150%	-48%	-8%	-54%	-2%	-64%	33%	-53%	-14%	-15%	8%	-12%	-38%	18%	-11%	27%	-10%	18%
mercury	20%	141%	60%	141%	80%	85%	620%	196%	580%	215%	-14%	-24%	-27%	18%	-64%	10%	-3%	-24%	21%	-11%
molybdenum	400%	464%	2,300%	3,991%	8,300%	4,355%	93,900%	14,445%	54,900%	10,809%	0%	-18%	-11%	-13%	-69%	-18%	12%	0%	4%	9%
monomer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
naphthenic acids – labile	-	-	-	-	-	-	-	-	-	-	-	-	-21%	-5%	18%	21%	-42%	-9%	-17%	56%
naphthenic acids – refractory	43%	44%	43%	0%	57%	9%	557%	112%	271%	24%	0%	0%	0%	0%	-42%	0%	12%	11%	4%	-5%
naphthenic acids – total	43%	44%	57%	3%	71%	18%	571%	115%	286%	26%	0%	0%	10%	3%	-40%	3%	9%	11%	4%	-7%
nickel	587%	57%	1,288%	1,509%	1,840%	2,161%	1,691%	1,074%	527%	143%	-4%	-10%	0%	-10%	-57%	-2%	-50%	-7%	0%	-13%
PAH group 1	-	-	-	-	-	-	-	-	-	-	-12%	-17%	16%	-9%	26%	43%	0%	-1%	20%	157%
PAH group 2	-	-	-	-	-	-	-	-	-	-	0%	0%	20%	-7%	-25%	52%	20%	10%	8%	0%
PAH group 3	-	-	-	-	-	-	-	-	-	-	0%	0%	-50%	-44%	0%	22%	-100%	14%	-100%	23%
PAH group 4	-	-	-	-	-	-	-	-	-	-	0%	0%	24%	16%	40%	61%	-31%	0%	0%	813%
PAH group 5	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	-29%	49%	156%	-23%	60%	23%	91%
PAH group 6	-	-	-	-	-	-	-	-	-	-	0%	0%	-75%	-44%	-81%	-15%	20%	-12%	-4%	-50%
PAH group 7	-	-	-	-	-	-	-	-	-	-	0%	0%	-50%	-48%	13%	129%	-33%	165%	35%	529%
PAH group 8	-	-	-	-	-	-	-	-	-	-	0%	0%	-50%	-44%	-23%	141%	-34%	2%	7%	63%
PAH group 9	-	-	-	-	-	-	-	-	-	-	0%	0%	7%	-33%	17%	32%	12%	-4%	22%	62%
potassium	106%	-29%	121%	-23%	34%	-37%	253%	-23%	179%	-16%	-13%	-15%	0%	-8%	-49%	-7%	0%	9%	0%	21%
selenium	-22%	-23%	-17%	-50%	0%	-54%	135%	-62%	100%	-58%	0%	0%	0%	-24%	-30%	-25%	6%	-17%	2%	-15%
silver	750%	2%	1,300%	38%	350%	-23%	800%	30%	600%	66%	-37%	-24%	-7%	-19%	-69%	-37%	-31%	3%	-33%	39%
sodium	51%	-37%	64%	-21%	78%	-5%	640%	67%	352%	21%	-15%	-5%	-8%	0%	-55%	-16%	0%	0%	-13%	-15%
strontium	92%	-7%	67%	-14%	42%	-10%	225%	0%	142%	-2%	0%	0%	-5%	-7%	-26%	8%	11%	9%	16%	14%
sulphate	375%	121%	500%	276%	400%	827%	2,825%	567%	1,050%	161%	0%	0%	14%	-12%	-51%	68%	30%	12%	21%	32%
sulphide	36%	-17%	-3%	-26%	-58%	-40%	-85%	-51%	-85%	-40%	0%	0%	3%	-8%	-26%	-26%	-29%	-36%	-29%	-28%
tainting potential	-	-	-	-	-	-	-	-	-	-	-	-	-22%	-7%	33%	48%	46%	120%	775%	324%
total dissolved solids	53%	-21%	38%	-25%	30%	-19%	177%	-7%	106%	-13%	0%	0%	-3%	-7%	-24%	5%	10%	3%	12%	11%
total nitrogen	-6%	-12%	-5%	-16%	0%	-12%	191%	40%	77%	-12%	0%	0%	-3%	-5%	-44%	-4%	21%	25%	8%	5%
total phenolics	54%	-17%	23%	-25%	-4%	-21%	-88%	-46%	-88%	-42%	0%	0%	3%	-10%	47%	6%	-25%	30%	-25%	27%
total phosphorus	203%	92%	203%	38%	27%	-13%	52%	29%	45%	-8%	0%	0%	0%	-15%	-42%	-25%	-2%	11%	20%	-12%
toxicity- acute	-	-	-	-	-	-	-	-	-	-	-	-	-20%	-8%	-83%	-65%	31%	76%	-15%	88%
toxicity- chronic	-	-	-	-	-	-	-	-	-	-	-	-	-22%	-7%	-49%	16%	-14%	17%	-8%	218%
vanadium	94%	16%	109%	9%	109%	3%	1,082%	122%	567%	91%	0%	0%	0%	-15%	-57%	-8%	18%	20%	-4%	39%
zinc	146%	163%	163%	132%	39%	32%	75%	-5%	51%	-8%	0%	0%	7%	-12%	-28%	39%	-9%	-5%	-28%	6%

Table 17-1 Percent and Absolute Change in Concentrations Predicted for M3 Under Application Case (continued)

	Absolute Change from Pre-development										Absolute Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	0.021	-0.16	0.039	-0.03	0.028	-0.12	0.17	-0.23	0.074	-0.32	-0.002	-0.07	0.015	-0.04	-0.066	-0.02	0.04	0	0	-0.03
ammonia	0.04	-1.1	0.048	-1.1	-0.009	-1.2	-0.027	-1.1	-0.025	-0.9	-0.026	-0.3	0.008	-0.2	-0.006	0.07	0.002	0.3	-0.006	0.32
antimony	0	-0.0009	0.00003	-0.0015	0	-0.0019	0.0002	-0.0022	0.00021	-0.0017	0	0	0.00001	-0.0008	-0.00022	-0.0007	-0.00011	-0.0005	-0.00022	-0.0003
arsenic	0.00017	0.0034	0.00035	0.0028	0.00005	-0.001	0.00033	0.0025	0.0002	-0.0009	-0.0001	-0.0014	0.00002	-0.0012	-0.00039	-0.0013	-0.0001	-0.0003	-0.00029	-0.0002
barium	0.054	-0.34	0.054	-0.31	0.002	-0.35	0.012	-0.29	0.026	-0.22	-0.013	-0.08	0	-0.07	-0.03	0.05	-0.007	0.14	0	0.17
beryllium	0.0001	0.0005	0.0001	0.0005	0.0001	0.0006	0.0004	0.0007	0.0002	0.0006	0	-0.0001	0	0	0	0.0001	0.0001	0	0	-0.0001
boron	0.016	-0.1	0.029	-0.05	0.051	-0.05	0.62	0.38	0.34	0.15	-0.003	-0.03	0.002	-0.03	-0.14	-0.05	0.09	0.06	0.02	0.05
cadmium	0.000001	-0.0008	0.000033	-0.0008	0.000073	-0.001	0.00028	-0.001	0.00023	-0.0008	-0.000012	-0.0003	-0.00001	-0.0004	-0.00018	-0.0003	-0.00011	-0.0001	-0.00016	-0.0001
calcium	49	49	38	25	11	13	6	-3	10	8	-1	-21	4	3	-1	23	3	37	7	41
chloride	1.7	-6	1.9	-3	6.5	10	46	57	26	38	0	-1	-0.5	-3	-6.8	1	4	-13	-3	-23
chromium	0.0013	0.04	0.0016	0.036	0.00036	0.029	0.0013	-0.0021	0.00046	-0.0025	-0.0002	-0.012	0.0001	-0.007	-0.0006	0.019	0.0002	0.0002	-0.0004	0.0003
cobalt	0.00041	0.0044	0.00066	0.0027	0.00011	0	0.00053	0.0001	0.00021	-0.0005	-0.00018	-0.0026	0.0001	-0.0006	-0.00038	-0.0013	0	-0.0001	-0.00012	0.0001
copper	0.00093	0.0016	0.0011	0.007	0.00029	0.0012	0.00093	-0.0001	0.00043	-0.0009	-0.0002	-0.0012	0.0001	-0.003	-0.00064	-0.0024	0.0001	-0.0009	0	-0.0002
dissolved organic carbon	2	-11	1	-13	-2	-12	4	-8	6	-4	-1	-2	0	-4	-4	2	0	6	2	7
iron	-0.2	-4.1	-0.27	-3.6	-0.27	-1	-0.51	-6.2	0.1	-5.6	0	0	-0.05	-1.7	0.03	4.2	-0.08	0.5	0.2	0.6
lead	0.00008	-0.0006	0.0001	-0.001	-0.00004	-0.0017	0.00008	-0.002	0.00008	-0.0017	0	0	0	-0.0001	-0.00021	-0.0004	-0.00006	-0.0003	-0.00023	-0.0004
magnesium	7	-17	5	-21	1	-21	1	-16	2	-9	0	-2	1	-5	0	6	0	14	1	18
manganese	0.068	-0.6	0.078	-0.82	-0.004	-0.91	-0.001	-1.1	0.017	-0.9	-0.02	-0.2	0.01	-0.12	-0.029	0.12	-0.006	0.13	-0.008	0.12
mercury	0.0000001	0.0000076	0.0000003	0.0000076	0.0000004	0.0000046	0.0000031	0.000011	0.0000029	0.000012	-0.0000001	-0.000004	-0.0000003	0.000002	-0.0000016	0.0000009	-0.0000001	-0.0000005	0.0000006	-0.000002
molybdenum	0.0004	0.0051	0.0023	0.044	0.0083	0.048	0.094	0.16	0.055	0.12	0	-0.0014	-0.0003	-0.007	-0.019	-0.011	0.01	0	0.002	0.01
monomer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
naphthenic acids – labile	0	0	0.022	0.36	0.11	0.47	0.11	0.48	0.091	0.53	0	0	-0.006	-0.02	0.017	0.08	-0.08	-0.05	-0.019	0.19
naphthenic acids – refractory	0.3	1.5	0.3	0	0.4	0.3	3.9	3.8	1.9	0.8	0	0	0	0	-0.8	0	0.5	0.7	0.1	-0.2
naphthenic acids – total	0.3	1.5	0.4	0.1	0.5	0.6	4	3.9	2	0.9	0	0	0.1	0.1	-0.8	0.1	0.4	0.7	0.1	-0.3
nickel	0.0039	0.013	0.0086	0.35	0.012	0.5	0.011	0.25	0.0035	0.033	-0.0002	-0.004	0	-0.04	-0.017	-0.01	-0.012	-0.02	0	-0.008
PAH group 1	0.0052	0.02	0.0064	0.021	0.0034	0.02	0.0014	0.0099	0.0006	0.0036	-0.0007	-0.004	0.0009	-0.002	0.0007	0.006	0	-0.0001	0.0001	0.0022
PAH group 2	0.01	0.044	0.012	0.043	0.0063	0.041	0.012	0.023	0.0053	0.012	0	0	0.002	-0.003	-0.0021	0.014	0.002	0.002	0.0004	0
PAH group 3	0	0.0006	0.0001	0.0015	0.0001	0.0011	0	0.0008	0	0.0008	0	0	-0.0001	-0.0012	0	0.0002	-0.0001	0.0001	-0.0001	0.00015
PAH group 4	0.02	0.081	0.021	0.099	0.012	0.092	0.0009	0.022	0.0004	0.021	0	0	0.004	0.014	0.0034	0.035	-0.0004	0	0	0.019
PAH group 5	0.01	0.049	0.011	0.092	0.0097	0.082	0.0041	0.04	0.0037	0.042	0	0	0	-0.038	0.0032	0.05	-0.0012	0.015	0.0007	0.02
PAH group 6	0.0001	0.0019	0.0001	0.0045	0.0003	0.004	0.0049	0.0097	0.0027	0.005	0	0	-0.0003	-0.0036	-0.0013	-0.0007	0.0008	-0.0013	-0.0001	-0.005
PAH group 7	0.0002	0.018	0.0006	0.04	0.0017	0.039	0.0028	0.045	0.0023	0.088	0	0	-0.0006	-0.037	0.0002	0.022	-0.0014	0.028	0.0006	0.074
PAH group 8	0.0003	0.049	0.0012	0.1	0.0034	0.094	0.0093	0.044	0.0061	0.049	0	0	-0.0012	-0.08	-0.001	0.055	-0.0047	0.001	0.0004	0.019
PAH group 9	0.0042	0.016	0.0048	0.016	0.0028	0.012	0.0019	0.0081	0.0011	0.0047	0	0	0.0003	-0.008	0.0004	0.0029	0.0002	-0.0003	0.0002	0.0018
potassium	0.72	-1.8	0.82	-1.4	0.23	-2.3	1.7	-1.4	1.2	-1	-0.2	-0.8	0	-0.4	-0.89	-0.3	0	0.4	0	0.9
selenium	-0.00005	-0.0006	-0.00004	-0.0013	0	-0.0014	0.00031	-0.0016	0.00023	-0.0015	0	0	0	-0.0004	-0.0001	-0.0004	0.00003	-0.0002	0.00001	-0.0002
silver	0.000015	0.000001	0.000026	0.000018	0.000007	-0.000011	0.000016	0.000014	0.000012	0.000031	-0.00001	-0.000015	-0.000002	-0.000015	-0.00002	-0.000021	-0.000008	0.000002	-0.000007	0.000022
sodium	3.7	-21	4.7	-12	5.7	-3	47	38	26	12	-2	-2	-1	0	-16	-10	0	0	-5	-12
strontium	0.11	-0.04	0.08	-0.08	0.05	-0.06	0.27	0	0.17	-0.01	0	0	-0.01	-0.04	-0.06	0.04	0.04	0.05	0.04	0.07
sulphate	15	40	20	91	16	273	113	187	42	53	0	0	3	-17	-21	124	27	24	8	21
sulphide	0.0012	-0.008	-0.0001	-0.012	-0.0019	-0.019	-0.0028	-0.024	-0.0028	-0.019	0	0	0.0001	-0.003	-0.0005	-0.01	-0.0002	-0.013	-0.0002	-0.011
tainting potential	0	0	0.0014	0.053	0.0076	0.083	0.06	0.22	0.056	0.14	0	0	-0.0004	-0.004	0.0019	0.027	0.019	0.12	0.05	0.11
total dissolved solids	106	-179	76	-217	59	-163	353	-61	211	-109	0	0	-8	-50	-80	36	49	22	45	74
total nitrogen	-0.05	-0.3	-0.04	-0.4	0	-0.3	1.5	1	0.61	-0.3	0	0	-0.02	-0.1	-0.61	-0.1	0.4	0.7	0.1	0.1
total phenolics	0.0014	-0.004	0.0006	-0.006	-0.0001	-0.005	-0.0023	-0.011	-0.0023	-0.01	0	0	0.0001	-0.002	0.0008	0.001	-0.0001	0.003	-0.0001	0.003
total phosphorus	0.067	0.22	0.067	0.09	0.009	-0.03	0.017	0.07	0.015	-0.02	0	0	0	-0.06	-0.031	-0.07	-0.001	0.03	0.008	-0.03
toxicity- acute	0	0	0.0004	0.0073	0.0029	0.014	0.042	0.088	0.0068	0.03	0	0	-0.0001	-0.0006	-0.014	-0.026	0.01	0.038	-0.0012	0.014
toxicity- chronic	0	0	0.0038	0.063	0.018	0.089	0.056	0.14	0.023	0.21	0	0	-0.0011	-0.005	-0.017	0.012	-0.009	0.02	-0.002	0.14
vanadium	0.00031	0.0005	0.00036	0.0003	0.00036	0.0001	0.0036	0.0039	0.0019	0.0029	0	0	0	-0.0006	-0.00091	-0.0003	0.0006	0.0012	-0.0001	0.0017
zinc	0.0083	0.062	0.0093	0.05	0.0022	0.012	0.0043	-0.002	0.0029	-0.003	0	0	0.001	-0.012	-0.0031	0.014	-0.001	-0.002	-0.0034	0.002

Table 17-2 Percent and Absolute Change in Concentrations Predicted for M2 Under Application Case

	Percent Change from Pre-development										Percent Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	47%	-19%	100%	-12%	78%	-19%	483%	-37%	206%	-42%	-7%	-9%	29%	-9%	-54%	-10%	24%	-10%	0%	-13%
ammonia	48%	-54%	123%	-52%	-23%	-72%	-63%	-64%	-63%	-58%	-41%	-19%	16%	-23%	-18%	-15%	15%	10%	-32%	20%
antimony	-4%	-17%	11%	-31%	0%	-47%	56%	-58%	56%	-56%	0%	0%	3%	-7%	-45%	-17%	-19%	-29%	-30%	-24%
arsenic	41%	89%	150%	167%	18%	-33%	127%	0%	73%	-47%	-31%	-39%	6%	-20%	-60%	-52%	-14%	0%	-42%	-26%
barium	144%	-47%	207%	-43%	19%	-62%	44%	-49%	93%	-41%	-22%	-20%	2%	-18%	-49%	-10%	-17%	23%	4%	29%
beryllium	-	-	-	-	-	-	-	-	-	-	0%	-33%	0%	-17%	0%	20%	33%	20%	0%	-20%
boron	29%	-21%	60%	-11%	108%	-16%	1,296%	64%	713%	33%	-5%	-9%	4%	-7%	-60%	-12%	16%	6%	11%	14%
cadmium	-8%	-32%	43%	-32%	90%	-44%	317%	-40%	257%	-32%	-23%	-19%	0%	-23%	-54%	-22%	-24%	-12%	-36%	-6%
calcium	111%	13%	109%	23%	34%	16%	17%	-3%	29%	7%	-4%	-19%	6%	6%	-2%	20%	8%	36%	22%	40%
chloride	73%	-24%	73%	10%	254%	48%	1,823%	197%	1,054%	134%	2%	-4%	-10%	-14%	-46%	8%	9%	-13%	-9%	-24%
chromium	102%	285%	186%	577%	43%	438%	150%	-35%	55%	-42%	-15%	-48%	4%	-17%	-33%	119%	11%	11%	-19%	6%
cobalt	121%	67%	347%	193%	63%	13%	268%	0%	100%	-36%	-36%	-64%	18%	-14%	-55%	-43%	3%	36%	-22%	-3%
copper	118%	55%	209%	186%	55%	48%	155%	-21%	82%	-29%	-20%	-7%	13%	-25%	-43%	-27%	0%	-25%	3%	-14%
dissolved organic carbon	12%	-19%	12%	-23%	-12%	-28%	29%	-17%	35%	-8%	-10%	-7%	0%	-9%	-25%	3%	0%	13%	5%	23%
iron	-8%	-37%	-24%	-35%	-25%	-10%	-46%	-62%	0%	-57%	0%	-2%	-5%	-22%	1%	89%	-12%	19%	20%	16%
lead	42%	-14%	53%	-32%	-21%	-54%	32%	-61%	32%	-57%	0%	0%	0%	-10%	-58%	-24%	-19%	-27%	-46%	-25%
magnesium	70%	-25%	50%	-32%	20%	-39%	20%	-28%	30%	-17%	0%	-4%	0%	-9%	0%	10%	0%	30%	8%	43%
manganese	96%	-56%	171%	-42%	-2%	-77%	-2%	-75%	29%	-68%	-28%	-41%	8%	-7%	-38%	-30%	-11%	-7%	-9%	9%
mercury	40%	156%	60%	202%	80%	156%	540%	40%	520%	33%	-13%	-31%	-27%	18%	-65%	22%	3%	-57%	29%	-48%
molybdenum	300%	580%	2,200%	4,300%	8,500%	5,700%	92,900%	16,900%	53,900%	11,900%	0%	-32%	-12%	-8%	-69%	-8%	13%	21%	8%	9%
monomer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
naphthenic acids – labile	-	-	-	-	-	-	-	-	-	-	-	-	-23%	-13%	16%	24%	-42%	-25%	-17%	50%
naphthenic acids – refractory	36%	33%	43%	3%	57%	12%	571%	118%	271%	27%	0%	0%	0%	-3%	-42%	-3%	15%	11%	8%	-5%
naphthenic acids – total	36%	33%	57%	3%	71%	21%	586%	121%	286%	36%	0%	0%	10%	-3%	-40%	0%	12%	11%	8%	-2%
nickel	452%	29%	1,288%	2,281%	1,840%	2,614%	1,840%	1,805%	527%	295%	-10%	-16%	0%	-11%	-58%	-5%	-48%	-9%	0%	-6%
PAH group 1	-	-	-	-	-	-	-	-	-	-	-20%	-30%	21%	-13%	30%	33%	0%	0%	17%	164%
PAH group 2	-	-	-	-	-	-	-	-	-	-	0%	0%	13%	-6%	-24%	55%	9%	44%	8%	17%
PAH group 3	-	-	-	-	-	-	-	-	-	-	0%	0%	-50%	-47%	0%	37%	-100%	13%	-100%	57%
PAH group 4	-	-	-	-	-	-	-	-	-	-	0%	0%	31%	11%	38%	60%	-33%	13%	25%	746%
PAH group 5	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	-34%	56%	158%	-23%	72%	22%	100%
PAH group 6	-	-	-	-	-	-	-	-	-	-	0%	0%	-60%	-50%	-81%	-19%	19%	-11%	-7%	-41%
PAH group 7	-	-	-	-	-	-	-	-	-	-	0%	0%	-54%	-51%	14%	129%	-33%	172%	33%	553%
PAH group 8	-	-	-	-	-	-	-	-	-	-	0%	0%	-54%	-47%	-25%	134%	-35%	-4%	8%	61%
PAH group 9	-	-	-	-	-	-	-	-	-	-	0%	0%	12%	-33%	21%	48%	19%	28%	22%	63%
potassium	75%	-37%	138%	-25%	37%	-51%	265%	-24%	186%	-22%	-21%	-23%	7%	-10%	-52%	-17%	0%	13%	6%	24%
selenium	-22%	-12%	-17%	-48%	0%	-52%	135%	-60%	96%	-60%	0%	0%	0%	-24%	-30%	-20%	8%	-17%	2%	-17%
silver	350%	-5%	1,300%	76%	350%	-3%	700%	27%	500%	114%	-57%	-47%	-3%	-19%	-69%	-37%	-33%	12%	-37%	126%
sodium	52%	-46%	82%	10%	97%	29%	718%	121%	385%	73%	-17%	-19%	0%	-4%	-57%	-6%	2%	12%	-9%	2%
strontium	83%	-8%	67%	-18%	42%	-20%	225%	-3%	142%	-7%	0%	0%	0%	-9%	-26%	4%	15%	12%	21%	14%
sulphate	300%	122%	475%	228%	400%	938%	2,825%	503%	1,050%	159%	0%	0%	21%	-15%	-52%	59%	30%	23%	21%	30%
sulphide	35%	-14%	-3%	-23%	-61%	-69%	-87%	-69%	-84%	-63%	0%	0%	3%	-13%	-33%	-54%	-33%	-58%	-29%	-50%
tainting potential	-	-	-	-	-	-	-	-	-	-	-	-	-21%	-8%	29%	21%	48%	191%	766%	315%
total dissolved solids	51%	-18%	40%	-25%	32%	-19%	185%	0%	109%	-14%	0%	0%	-2%	-9%	-24%	4%	12%	8%	16%	9%
total nitrogen	-3%	-8%	-3%	-16%	3%	-4%	199%	40%	82%	-16%	0%	0%	0%	-5%	-44%	4%	28%	30%	17%	11%
total phenolics	44%	-12%	15%	-27%	-4%	-27%	-89%	-42%	-89%	-35%	0%	0%	3%	-10%	53%	0%	-25%	25%	-14%	42%
total phosphorus	184%	120%	213%	50%	28%	-10%	44%	-30%	44%	-25%	0%	0%	5%	-12%	-44%	-38%	-2%	-26%	28%	-21%
toxicity- acute	-	-	-	-	-	-	-	-	-	-	-	-	-33%	-9%	-86%	-74%	34%	112%	-16%	53%
toxicity- chronic	-	-	-	-	-	-	-	-	-	-	-	-	-23%	-7%	-50%	2%	-15%	42%	-12%	125%
vanadium	84%	3%	113%	20%	113%	10%	1,119%	137%	556%	60%	0%	0%	1%	-18%	-58%	-8%	22%	42%	5%	12%
zinc	114%	153%	150%	147%	41%	42%	79%	-19%	46%	-19%	0%	0%	8%	-11%	-28%	42%	0%	21%	-25%	16%

Table 17-2 Percent and Absolute Change in Concentrations Predicted for M2 Under Application Case (continued)

	Absolute Change from Pre-development										Absolute Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	0.017	-0.17	0.036	-0.11	0.028	-0.17	0.17	-0.33	0.074	-0.38	-0.004	-0.07	0.016	-0.08	-0.076	-0.08	0.04	-0.06	0	-0.08
ammonia	0.019	-1.1	0.049	-1.1	-0.009	-1.5	-0.025	-1.3	-0.025	-1.2	-0.041	-0.23	0.012	-0.3	-0.007	-0.1	0.002	0.07	-0.007	0.15
antimony	-0.00001	-0.0006	0.00003	-0.0011	0	-0.0017	0.00015	-0.0021	0.00015	-0.002	0	0	0.00001	-0.0002	-0.00022	-0.0004	-0.0001	-0.0006	-0.00018	-0.0005
arsenic	0.00009	0.0016	0.00033	0.003	0.00004	-0.0006	0.00028	0	0.00016	-0.00084	-0.00014	-0.0022	0.00003	-0.0012	-0.00039	-0.0013	-0.00008	0	-0.00027	-0.00034
barium	0.039	-0.35	0.056	-0.32	0.005	-0.46	0.012	-0.36	0.025	-0.3	-0.019	-0.1	0.002	-0.09	-0.031	-0.03	-0.008	0.07	0.002	0.1
beryllium	0.0001	0.0004	0.0001	0.0005	0.0001	0.0006	0.0004	0.0006	0.0002	0.0004	0	-0.0002	0	-0.0001	0	0.0001	0.0001	0.0001	0	-0.0001
boron	0.014	-0.13	0.029	-0.07	0.052	-0.1	0.62	0.39	0.34	0.2	-0.003	-0.05	0.003	-0.04	-0.15	-0.07	0.09	0.06	0.04	0.1
cadmium	-0.000007	-0.0008	0.000036	-0.0008	0.000076	-0.0011	0.00027	-0.001	0.00022	-0.0008	-0.000023	-0.0004	0	-0.0005	-0.00019	-0.0004	-0.00011	-0.0002	-0.00017	-0.0001
calcium	39	18	38	31	12	22	6	-4	10	10	-3	-36	4	10	-1	27	3	35	8	42
chloride	1.9	-7	1.9	3	6.6	14	47	57	27	39	0.1	-1	-0.5	-5	-7.8	3	4	-13	-3	-22
chromium	0.00086	0.019	0.0016	0.038	0.00036	0.029	0.0013	-0.0023	0.00046	-0.0027	-0.0003	-0.023	0.0001	-0.009	-0.0006	0.019	0.0002	0.0004	-0.0003	0.0002
cobalt	0.00023	0.001	0.00066	0.0029	0.00012	0.0002	0.00051	0	0.00019	-0.00054	-0.00024	-0.0045	0.00013	-0.0007	-0.00038	-0.0013	0.00002	0.0004	-0.00011	-0.00003
copper	0.00065	0.0023	0.0012	0.0078	0.0003	0.002	0.00085	-0.0009	0.00045	-0.0012	-0.0003	-0.0005	0.0002	-0.004	-0.00065	-0.0023	0	-0.0011	0.00003	-0.0005
dissolved organic carbon	2	-10	2	-12	-2	-15	5	-9	6	-4	-2	-3	0	-4	-5	1	0	5	1	9
iron	-0.1	-3.7	-0.29	-3.5	-0.3	-1	-0.55	-6.1	0	-5.6	0	-0.1	-0.05	-1.8	0.01	4.2	-0.09	0.6	0.2	0.6
lead	0.00008	-0.0004	0.0001	-0.0009	-0.00004	-0.0015	0.00006	-0.0017	0.00006	-0.0016	0	0	0	-0.0002	-0.00021	-0.0004	-0.00006	-0.0004	-0.00021	-0.0004
magnesium	7	-18	5	-23	2	-28	2	-20	3	-12	0	-2	0	-5	0	4	0	12	1	18
manganese	0.046	-0.89	0.082	-0.67	-0.001	-1.2	-0.001	-1.2	0.014	-1.1	-0.036	-0.49	0.01	-0.07	-0.029	-0.16	-0.006	-0.03	-0.006	0.04
mercury	0.0000002	0.0000067	0.0000003	0.0000087	0.0000004	0.0000067	0.0000027	0.0000017	0.0000026	0.0000014	-0.0000001	-0.0000005	-0.0000003	0.0000002	-0.0000017	0.0000002	0.0000001	-0.0000008	0.0000007	-0.0000053
molybdenum	0.0003	0.0058	0.0022	0.043	0.0085	0.057	0.093	0.17	0.054	0.12	0	-0.0032	-0.0003	-0.004	-0.019	-0.005	0.011	0.03	0.004	0.01
monomer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
naphthenic acids – labile	0	0	0.023	0.48	0.1	0.47	0.11	0.46	0.091	0.54	0	0	-0.007	-0.07	0.014	0.09	-0.08	-0.15	-0.019	0.18
naphthenic acids – refractory	0.25	1.1	0.3	0.1	0.4	0.4	4	3.9	1.9	0.9	0	0	0	-0.1	-0.8	-0.1	0.6	0.7	0.2	-0.2
naphthenic acids – total	0.25	1.1	0.4	0.1	0.5	0.7	4.1	4	2	1.2	0	0	0.1	-0.1	-0.8	0	0.5	0.7	0.2	-0.1
nickel	0.003	0.006	0.0086	0.48	0.012	0.55	0.012	0.38	0.0035	0.062	-0.0004	-0.005	0	-0.06	-0.018	-0.03	-0.012	-0.04	0	-0.005
PAH group 1	0.0036	0.016	0.0064	0.021	0.0035	0.02	0.0014	0.0067	0.0007	0.0037	-0.0009	-0.007	0.0011	-0.003	0.0008	0.005	0	0	0.0001	0.0023
PAH group 2	0.0085	0.042	0.011	0.044	0.0065	0.045	0.012	0.026	0.0055	0.014	0	0	0.0013	-0.003	-0.0021	0.016	0.001	0.008	0.0004	0.002
PAH group 3	0.0001	0.001	0.0001	0.0017	0.0001	0.0013	0	0.0009	0	0.0011	0	0	-0.0001	-0.0015	0	0.00035	-0.0001	0.0001	-0.0001	0.0004
PAH group 4	0.015	0.082	0.021	0.097	0.012	0.096	0.0008	0.017	0.0005	0.022	0	0	0.005	0.01	0.0033	0.036	-0.0004	0.002	0.0001	0.019
PAH group 5	0.0078	0.06	0.011	0.093	0.01	0.085	0.0041	0.043	0.0039	0.046	0	0	0	-0.047	0.0036	0.052	-0.0012	0.018	0.0007	0.023
PAH group 6	0.0001	0.003	0.0002	0.0049	0.0003	0.0038	0.0051	0.0098	0.0028	0.0059	0	0	-0.0003	-0.0049	-0.0013	-0.0009	0.0008	-0.0012	-0.0002	-0.0041
PAH group 7	0.0002	0.036	0.0006	0.042	0.0016	0.039	0.0029	0.049	0.0024	0.098	0	0	-0.0007	-0.044	0.0002	0.022	-0.0014	0.031	0.0006	0.083
PAH group 8	0.0004	0.079	0.0012	0.1	0.0033	0.096	0.0097	0.044	0.0064	0.05	0	0	-0.0014	-0.09	-0.0011	0.055	-0.0053	-0.002	0.0005	0.019
PAH group 9	0.0033	0.014	0.0048	0.016	0.0029	0.013	0.0019	0.0068	0.0011	0.0049	0	0	0.0005	-0.008	0.0005	0.0042	0.0003	0.0015	0.0002	0.0019
potassium	0.47	-2.2	0.87	-1.5	0.23	-3	1.7	-1.4	1.2	-1.3	-0.3	-1.1	0.1	-0.5	-0.94	-0.6	0	0.5	0.1	0.9
selenium	-0.00005	-0.0003	-0.00004	-0.0012	0	-0.0013	0.00031	-0.0015	0.00022	-0.0015	0	0	0	-0.0004	-0.0001	-0.0003	0.00004	-0.0002	0.00001	-0.0002
silver	0.000007	-0.000002	0.000026	0.000028	0.000007	-0.000001	0.000014	0.00001	0.00001	0.000042	-0.000012	-0.000031	-0.000001	-0.000015	-0.00002	-0.000021	-0.000008	0.000005	-0.000007	0.000044
sodium	3.4	-22	5.4	5	6.4	14	47	58	25	35	-2	-6	0	-2	-17	-4	1	11	-3	2
strontium	0.1	-0.05	0.08	-0.11	0.05	-0.12	0.27	-0.02	0.17	-0.04	0	0	0	-0.05	-0.06	0.02	0.05	0.06	0.05	0.07
sulphate	12	39	19	73	16	300	113	161	42	51	0	0	4	-19	-22	123	27	36	8	19
sulphide	0.0011	-0.005	-0.0001	-0.008	-0.0019	-0.024	-0.0027	-0.024	-0.0026	-0.022	0	0	0.0001	-0.004	-0.0006	-0.013	-0.0002	-0.015	-0.0002	-0.013
tainting potential	0	0	0.0015	0.07	0.0067	0.081	0.062	0.32	0.058	0.17	0	0	-0.0004	-0.006	0.0015	0.014	0.02	0.21	0.051	0.13
total dissolved solids	100	-155	78	-208	62	-164	360	0	212	-117	0	0	-6	-63	-81	27	60	61	56	63
total nitrogen	-0.02	-0.2	-0.02	-0.4	0.02	-0.1	1.5	1	0.63	-0.4	0	0	0	-0.1	-0.61	0.1	0.5	0.8	0.2	0.2
total phenolics	0.0012	-0.003	0.0004	-0.007	-0.0001	-0.007	-0.0024	-0.011	-0.0024	-0.009	0	0	0.0001	-0.002	0.0009	0	-0.0001	0.003	-0.00005	0.005
total phosphorus	0.059	0.24	0.068	0.1	0.009	-0.02	0.014	-0.06	0.014	-0.05	0	0	0.005	-0.04	-0.032	-0.11	-0.001	-0.05	0.01	-0.04
toxicity- acute	0	0	0.0004	0.0091	0.0023	0.01	0.043	0.11	0.0068	0.023	0	0	-0.0002	-0.0009	-0.015	-0.029	0.011	0.058	-0.0013	0.008
toxicity- chronic	0	0	0.004	0.086	0.017	0.086	0.056	0.17	0.023	0.16	0	0	-0.0012	-0.006	-0.017	0.002	-0.01	0.05	-0.003	0.089
vanadium	0.00027	0.0001	0.00036	0.0006	0.00036	0.0003	0.0036	0.0041	0.0018	0.0018	0	0	0.00001	-0.0008	-0.00092	-0.0003	0.0007	0.0021	0.0001	0.0005
zinc	0.0064	0.055	0.0084	0.053	0.0023	0.015	0.0044	-0.007	0.0026	-0.007	0	0	0.001	-0.011	-0.0031	0.015	0	0.005	-0.0028	0.004

Table 17-3 Percent and Absolute Change in Concentrations Predicted for M1 Under Application Case

	Percent Change from Pre-development										Percent Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	45%	-20%	105%	-7%	89%	-16%	532%	-48%	216%	-60%	-7%	-12%	32%	-5%	-52%	-11%	26%	-22%	0%	-37%
ammonia	70%	-53%	164%	-50%	-36%	-80%	-70%	-72%	-70%	-60%	-44%	-27%	16%	-29%	-42%	-42%	5%	-11%	24%	19%
antimony	-7%	-3%	11%	-22%	-11%	-69%	59%	-76%	59%	-74%	0%	0%	3%	-26%	-49%	-61%	-16%	-68%	-30%	-67%
arsenic	37%	100%	211%	167%	21%	-28%	184%	-17%	105%	-51%	-37%	-40%	7%	-23%	-67%	-52%	-11%	7%	-44%	-32%
barium	192%	-52%	279%	-44%	33%	-76%	67%	-64%	129%	-48%	-23%	-27%	1%	-22%	-52%	-36%	-18%	-13%	4%	18%
beryllium	-	-	-	-	-	-	-	-	-	-	0%	-29%	0%	0%	-50%	20%	25%	0%	50%	-20%
boron	34%	-21%	74%	-4%	134%	-9%	15,60%	93%	857%	46%	-6%	-17%	4%	-7%	-61%	-9%	20%	16%	15%	17%
cadmium	-13%	-39%	65%	-48%	103%	-60%	406%	-52%	318%	-52%	-28%	-26%	0%	-37%	-57%	-29%	-20%	10%	-34%	0%
calcium	139%	16%	142%	26%	45%	20%	27%	-14%	39%	-1%	-4%	-21%	7%	6%	-6%	21%	8%	28%	21%	38%
chloride	85%	-10%	88%	28%	323%	76%	2,015%	224%	1,169%	169%	2%	0%	-11%	-14%	-42%	19%	4%	-6%	-13%	-14%
chromium	118%	574%	233%	970%	41%	807%	182%	0%	67%	-56%	-15%	-48%	8%	-21%	-39%	117%	16%	19%	-19%	-21%
cobalt	163%	123%	494%	254%	94%	38%	394%	23%	156%	-25%	-39%	-65%	16%	-13%	-60%	-47%	7%	33%	-21%	-2%
copper	136%	73%	245%	225%	62%	58%	191%	-8%	100%	-8%	-19%	-10%	12%	-24%	-48%	-28%	7%	-29%	10%	-12%
dissolved organic carbon	12%	-23%	12%	-28%	-12%	-45%	29%	-28%	41%	-9%	-10%	-7%	-5%	-14%	-25%	-17%	0%	-19%	9%	4%
iron	0%	-52%	-19%	-27%	-24%	3%	-45%	-83%	9%	-71%	0%	-10%	-4%	-21%	-2%	126%	-13%	-30%	20%	4%
lead	47%	-8%	71%	-16%	-29%	-74%	47%	-77%	47%	-70%	0%	0%	0%	-16%	-67%	-60%	-19%	-55%	-48%	-54%
magnesium	70%	-26%	60%	-36%	20%	-52%	20%	-40%	30%	-18%	0%	-2%	0%	-15%	0%	-5%	0%	22%	8%	54%
manganese	133%	-53%	226%	-38%	-2%	-78%	9%	-77%	49%	-64%	-23%	-42%	17%	-9%	-48%	-38%	-11%	-16%	-7%	21%
mercury	40%	179%	20%	226%	40%	179%	600%	91%	560%	86%	17%	-29%	-33%	17%	-74%	9%	0%	-37%	32%	-18%
molybdenum	300%	420%	2,600%	4,900%	10,900%	6,600%	109,900%	16,900%	64,900%	11,900%	0%	-26%	-16%	-11%	-68%	-1%	16%	13%	14%	9%
monomer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
naphthenic acids – labile	-	-	-	-	-	-	-	-	-	-	-	-	-29%	-16%	30%	46%	-52%	-46%	-19%	117%
naphthenic acids – refractory	40%	50%	57%	22%	71%	25%	671%	125%	314%	47%	0%	0%	10%	3%	-43%	-2%	17%	9%	12%	4%
naphthenic acids – total	40%	50%	57%	22%	86%	31%	686%	131%	329%	53%	0%	0%	0%	0%	-41%	0%	12%	10%	11%	7%
nickel	500%	45%	1,329%	2,627%	2,329%	2,764%	1,900%	1,900%	571%	300%	-7%	-11%	0%	-24%	-56%	-6%	-55%	-10%	7%	-9%
PAH group 1	-	-	-	-	-	-	-	-	-	-	-12%	-32%	15%	-13%	31%	47%	7%	6%	40%	85%
PAH group 2	-	-	-	-	-	-	-	-	-	-	0%	0%	18%	-7%	-18%	43%	25%	59%	12%	17%
PAH group 3	-	-	-	-	-	-	-	-	-	-	-	-	-100%	-93%	-100%	20%	-	-100%	-	-100%
PAH group 4	-	-	-	-	-	-	-	-	-	-	0%	0%	26%	15%	60%	52%	-50%	13%	50%	55%
PAH group 5	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	-56%	55%	40%	-40%	-30%	14%	112%
PAH group 6	-	-	-	-	-	-	-	-	-	-	-	-	-100%	-51%	-94%	-30%	24%	0%	-3%	-33%
PAH group 7	-	-	-	-	-	-	-	-	-	-	-	-	-75%	-75%	14%	46%	-46%	-21%	27%	22%
PAH group 8	-	-	-	-	-	-	-	-	-	-	-	-	-71%	-87%	-27%	64%	-42%	-19%	7%	55%
PAH group 9	-	-	-	-	-	-	-	-	-	-	0%	0%	6%	-6%	27%	21%	29%	31%	33%	44%
potassium	94%	-39%	158%	-15%	42%	-53%	319%	-17%	223%	-19%	-20%	-28%	0%	-11%	-56%	-22%	0%	17%	0%	26%
selenium	-22%	-13%	-17%	-60%	-4%	-62%	152%	-67%	104%	-66%	0%	0%	0%	-34%	-33%	-13%	12%	-22%	4%	-21%
silver	900%	-3%	2,800%	51%	600%	-35%	1,600%	11%	1,100%	-24%	-52%	-39%	-3%	-20%	-78%	-54%	-32%	2%	-37%	-15%
sodium	72%	-40%	107%	27%	159%	46%	969%	133%	521%	90%	-17%	-17%	-8%	-8%	-56%	0%	5%	15%	-8%	12%
strontium	109%	-8%	91%	-16%	55%	-21%	291%	5%	182%	10%	0%	0%	-5%	-9%	-29%	2%	16%	-2%	24%	21%
sulphate	336%	131%	541%	247%	515%	953%	3,438%	556%	1,259%	178%	0%	0%	14%	-9%	-51%	35%	35%	26%	26%	39%
sulphide	52%	3%	7%	17%	-78%	-68%	-96%	-67%	-100%	-57%	0%	0%	7%	-13%	-60%	-67%	-50%	-73%	-100%	-64%
tainting potential	-	-	-	-	-	-	-	-	-	-	-	-	-25%	0%	34%	30%	56%	94%	915%	309%
total dissolved solids	61%	-20%	48%	-24%	38%	-16%	224%	18%	131%	5%	0%	0%	-3%	-11%	-26%	9%	14%	26%	17%	34%
total nitrogen	-4%	-13%	-3%	-25%	3%	8%	238%	54%	82%	13%	0%	0%	0%	-10%	-47%	8%	37%	37%	8%	50%
total phenolics	41%	-16%	11%	-40%	-15%	-44%	-100%	-84%	-100%	-82%	0%	0%	7%	-12%	44%	8%	-100%	-11%	-100%	-10%
total phosphorus	234%	137%	279%	68%	41%	0%	72%	5%	62%	26%	0%	0%	10%	-11%	-49%	-41%	4%	-38%	27%	-25%
toxicity- acute	-	-	-	-	-	-	-	-	-	-	-	-	-29%	-23%	-85%	-68%	41%	126%	1%	167%
toxicity- chronic	-	-	-	-	-	-	-	-	-	-	-	-	-26%	-9%	-44%	18%	-16%	13%	-5%	303%
vanadium	100%	40%	147%	52%	137%	52%	1,400%	196%	700%	100%	0%	0%	3%	-17%	-61%	6%	25%	45%	9%	16%
zinc	140%	191%	200%	171%	46%	56%	100%	-38%	68%	-50%	0%	0%	15%	-8%	-34%	43%	0%	-9%	-24%	-32%

Table 17-3 Percent and Absolute Change in Concentrations Predicted for M1 Under Application Case (continued)

	Absolute Change from Pre-development										Absolute Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	0.017	-0.17	0.04	-0.06	0.034	-0.14	0.2	-0.41	0.082	-0.52	-0.004	-0.09	0.019	-0.04	-0.078	-0.09	0.05	-0.13	0	-0.2
ammonia	0.023	-1	0.054	-1	-0.012	-1.6	-0.023	-1.4	-0.023	-1.2	-0.044	-0.35	0.012	-0.4	-0.015	-0.3	0.0005	-0.07	0.0019	0.13
antimony	-0.00002	-0.0001	0.00003	-0.0007	-0.00003	-0.0022	0.00016	-0.0024	0.00016	-0.0024	0	0	0.00001	-0.0009	-0.00023	-0.0015	-0.00008	-0.0016	-0.00018	-0.0017
arsenic	0.00007	0.0018	0.0004	0.003	0.00004	-0.0005	0.00035	-0.0003	0.0002	-0.00091	-0.00015	-0.0024	0.00004	-0.0014	-0.00046	-0.0014	-0.00007	0.0001	-0.00031	-0.00041
barium	0.046	-0.39	0.067	-0.33	0.008	-0.57	0.016	-0.48	0.031	-0.36	-0.021	-0.13	0.001	-0.12	-0.035	-0.1	-0.009	-0.04	0.002	0.06
beryllium	0.0001	0.0005	0.0001	0.0006	0.0001	0.0006	0.0005	0.0006	0.0003	0.0004	0	-0.0002	0	0	-0.0001	0.0001	0.0001	0	0.0001	-0.0001
boron	0.016	-0.12	0.035	-0.02	0.063	-0.05	0.73	0.53	0.4	0.26	-0.004	-0.09	0.003	-0.04	-0.17	-0.05	0.13	0.15	0.06	0.12
cadmium	-0.00001	-0.0009	0.000051	-0.0011	0.000081	-0.0014	0.00032	-0.0012	0.00025	-0.0012	-0.000027	-0.0005	0	-0.0007	-0.00021	-0.00038	-0.0001	0.0001	-0.00017	0
calcium	46	22	47	36	15	28	9	-20	13	-2	-3	-43	5	10	-3	29	3	26	8	38
chloride	2.2	-3	2.3	8	8.4	22	52	65	30	49	0.1	0	-0.6	-6	-8	8	2	-6	-5	-13
chromium	0.00092	0.025	0.0018	0.042	0.00032	0.035	0.0014	0	0.00052	-0.0024	-0.0003	-0.027	0.0002	-0.012	-0.0007	0.021	0.0003	0.0007	-0.0003	-0.0005
cobalt	0.00026	0.0016	0.00079	0.0033	0.00015	0.0005	0.00063	0.0003	0.00025	-0.00032	-0.00027	-0.0053	0.00013	-0.0007	-0.00046	-0.0016	0.00005	0.0004	-0.00011	-0.00002
copper	0.00075	0.0029	0.0014	0.009	0.00034	0.0023	0.0011	-0.0003	0.00055	-0.0003	-0.0003	-0.0008	0.0002	-0.004	-0.00081	-0.0024	0.0001	-0.0015	0.0001	-0.0005
dissolved organic carbon	2	-12	2	-15	-2	-24	5	-15	7	-5	-2	-3	-1	-6	-5	-6	0	-9	2	2
iron	0	-4.8	-0.21	-2.5	-0.26	0.3	-0.49	-7.6	0.1	-6.5	0	-0.5	-0.04	-1.8	-0.02	5.3	-0.09	-0.7	0.2	0.1
lead	0.00008	-0.0002	0.00012	-0.0004	-0.00005	-0.0019	0.00008	-0.0019	0.00008	-0.0018	0	0	0	-0.0004	-0.00024	-0.00096	-0.00006	-0.00072	-0.00023	-0.00086
magnesium	7	-19	6	-26	2	-38	2	-29	3	-13	0	-1	0	-8	0	-2	0	8	1	21
manganese	0.057	-0.85	0.097	-0.6	-0.001	-1.2	0.004	-1.2	0.021	-1	-0.03	-0.55	0.02	-0.1	-0.039	-0.21	-0.006	-0.07	-0.005	0.1
mercury	0.0000002	0.0000077	0.0000001	0.0000097	0.0000002	0.0000077	0.0000003	0.0000039	0.0000028	0.0000037	0.0000001	-0.000005	-0.0000003	0.000002	-0.000002	0.000001	0	-0.0000048	0.0000008	-0.0000018
molybdenum	0.0003	0.0042	0.0026	0.049	0.011	0.066	0.11	0.17	0.065	0.12	0	-0.0018	-0.0005	-0.006	-0.023	-0.001	0.015	0.02	0.008	0.01
monomer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
naphthenic acids – labile	0	0	0.027	0.57	0.13	0.6	0.1	0.5	0.07	0.65	0	0	-0.011	-0.11	0.03	0.19	-0.11	-0.42	-0.016	0.35
naphthenic acids – refractory	0.28	1.6	0.4	0.7	0.5	0.8	4.7	4	2.2	1.5	0	0	0.1	0.1	-0.9	-0.1	0.8	0.6	0.3	0.2
naphthenic acids – total	0.28	1.6	0.4	0.7	0.6	1	4.8	4.2	2.3	1.7	0	0	0	0	-0.9	0	0.6	0.7	0.3	0.3
nickel	0.0035	0.01	0.0093	0.58	0.016	0.61	0.013	0.42	0.004	0.066	-0.0003	-0.004	0	-0.19	-0.022	-0.04	-0.017	-0.05	0.0003	-0.009
PAH group 1	0.0044	0.017	0.0071	0.021	0.0042	0.022	0.0016	0.0066	0.0007	0.0024	-0.0006	-0.008	0.0009	-0.003	0.001	0.007	0.0001	0.0004	0.0002	0.0011
PAH group 2	0.0092	0.043	0.013	0.043	0.008	0.043	0.015	0.027	0.0065	0.014	0	0	0.002	-0.003	-0.0018	0.013	0.003	0.01	0.0007	0.002
PAH group 3	0	0	0	0.0001	0	0.0003	0	0	0	0	0	0	-0.0001	-0.0013	-0.0001	0.00005	0	-0.0002	0	-0.0001
PAH group 4	0.017	0.085	0.024	0.1	0.016	0.1	0.0006	0.017	0.0003	0.0034	0	0	0.005	0.013	0.006	0.034	-0.0006	0.002	0.0001	0.0012
PAH group 5	0.0081	0.028	0.012	0.032	0.011	0.042	0.0028	0.014	0.0025	0.021	0	0	0	-0.04	0.0039	0.012	-0.0019	-0.006	0.0003	0.011
PAH group 6	0	0	0	0.0021	0.0001	0.0026	0.0061	0.011	0.0033	0.0067	0	0	-0.0003	-0.0022	-0.0016	-0.0011	0.0012	0	-0.0001	-0.0033
PAH group 7	0	0	0.0003	0.01	0.0016	0.012	0.0025	0.011	0.0019	0.01	0	0	-0.0009	-0.03	0.0002	0.0038	-0.0021	-0.003	0.0004	0.0018
PAH group 8	0	0	0.0007	0.012	0.0033	0.023	0.0099	0.025	0.0059	0.017	0	0	-0.0017	-0.081	-0.0012	0.009	-0.0071	-0.006	0.0004	0.006
PAH group 9	0.0035	0.015	0.0051	0.015	0.0033	0.011	0.0022	0.0067	0.0012	0.0036	0	0	0.0003	-0.001	0.0007	0.0019	0.0005	0.0016	0.0003	0.0011
potassium	0.58	-2.3	0.98	-0.9	0.26	-3.1	2	-1	1.4	-1.1	-0.3	-1.4	0	-0.6	-1.1	-0.8	0	0.7	0	1
selenium	-0.00005	-0.0003	-0.00004	-0.0014	-0.00001	-0.0014	0.00035	-0.0015	0.00024	-0.0015	0	0	0	-0.00047	-0.00011	-0.00013	0.00006	-0.00022	0.00002	-0.00021
silver	0.000009	-0.000001	0.000028	0.000019	0.000006	-0.000013	0.000016	0.000004	0.000011	-0.000009	-0.000011	-0.000023	-0.000001	-0.000014	-0.000025	-0.000028	-0.000008	0.000001	-0.000007	-0.000005
sodium	4.2	-19	6.2	13	9.2	22	56	64	30	43	-2	-6	-1	-5	-19	0	3	15	-3	10
strontium	0.12	-0.05	0.1	-0.1	0.06	-0.13	0.32	0.03	0.2	0.06	0	0	-0.01	-0.05	-0.07	0.01	0.06	-0.01	0.06	0.12
sulphate	13	42	21	79	20	305	134	178	49	57	0	0	3	-11	-25	88	36	43	11	25
sulphide	0.0014	0.001	0.0002	0.005	-0.0021	-0.02	-0.0026	-0.02	-0.0027	-0.017	0	0	0.0002	-0.005	-0.0009	-0.019	-0.0001	-0.027	-0.0002	-0.023
tainting potential	0	0	0.0018	0.1	0.0086	0.1	0.078	0.35	0.068	0.18	0	0	-0.0006	0	0.0022	0.023	0.028	0.17	0.061	0.14
total dissolved solids	116	-178	91	-216	73	-146	426	158	248	41	0	0	-10	-84	-93	61	74	213	65	235
total nitrogen	-0.03	-0.3	-0.02	-0.6	0.02	0.2	1.8	1.3	0.63	0.3	0	0	0	-0.2	-0.71	0.2	0.7	1	0.1	0.9
total phenolics	0.0011	-0.004	0.0003	-0.01	-0.0004	-0.011	-0.0027	-0.021	-0.0027	-0.02	0	0	0.0002	-0.002	0.0007	0.001	-0.0001	-0.0005	-0.0001	-0.0005
total phosphorus	0.068	0.26	0.081	0.13	0.012	0	0.021	0.01	0.018	0.05	0	0	0.01	-0.04	-0.039	-0.13	0.002	-0.12	0.01	-0.08
toxicity- acute	0	0	0.0005	0.01	0.0031	0.013	0.052	0.12	0.0074	0.032	0	0	-0.0002	-0.003	-0.018	-0.027	0.015	0.067	0.0001	0.02
toxicity- chronic	0	0	0.0048	0.1	0.023	0.11	0.062	0.17	0.02	0.27	0	0	-0.0017	-0.01	-0.018	0.017	-0.012	0.02	-0.001	0.2
vanadium	0.0003	0.001	0.00044	0.0013	0.00041	0.0013	0.0042	0.0049	0.0021	0.0025	0	0	0.00002	-0.0008	-0.0011	0.0002	0.0009	0.0023	0.0002	0.0007
zinc	0.007	0.065	0.01	0.058	0.0023	0.019	0.005	-0.013	0.0034	-0.017	0	0	0.002	-0.008	-0.0037	0.016	0	-0.002	-0.0026	-0.008

Table 17-4 Percent and Absolute Change in Concentrations Predicted for M0 Under Application Case

	Percent Change from Pre-development										Percent Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	15%	-11%	0%	4%	85%	15%	809%	-63%	294%	-85%	9%	-1%	3%	0%	5%	10%	30%	-37%	8%	-75%
ammonia	-26%	-15%	-37%	15%	-9%	-45%	-99%	-100%	-99%	-99%	-2%	6%	14%	0%	3%	0%	-83%	-99%	-78%	-99%
antimony	-77%	-65%	-66%	-51%	-67%	-81%	-36%	-95%	-38%	-95%	0%	0%	0%	0%	11%	-22%	11%	-78%	-2%	-79%
arsenic	-73%	-76%	-58%	-58%	15%	58%	23%	-91%	-20%	-94%	0%	0%	0%	-11%	15%	8%	14%	-49%	10%	-67%
barium	56%	9%	32%	40%	144%	-64%	0%	-93%	29%	-89%	6%	3%	10%	1%	0%	-46%	6%	-89%	100%	-91%
beryllium	-	-	-	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	20%	-14%	50%	-43%
boron	29%	-7%	17%	16%	60%	-20%	1,948%	64%	876%	-13%	2%	0%	2%	11%	10%	-6%	23%	0%	46%	13%
cadmium	-67%	-72%	-57%	-68%	-36%	-75%	80%	-94%	47%	-96%	0%	-5%	2%	0%	14%	20%	13%	-52%	29%	-69%
calcium	67%	15%	27%	26%	147%	70%	33%	-58%	47%	-53%	2%	4%	3%	-1%	6%	5%	18%	-54%	52%	-64%
chloride	233%	35%	67%	31%	54%	-23%	1,817%	146%	650%	4%	4%	-8%	8%	0%	-12%	-5%	64%	19%	80%	-13%
chromium	-33%	-35%	3%	2%	228%	1,922%	288%	-35%	79%	-67%	2%	0%	0%	-51%	16%	21%	18%	3%	9%	-12%
cobalt	-42%	-58%	-29%	-27%	246%	250%	221%	-63%	33%	-83%	8%	0%	0%	-41%	15%	12%	24%	-5%	39%	-61%
copper	-25%	-18%	-36%	5%	90%	400%	80%	-68%	10%	-81%	6%	-2%	0%	-10%	12%	11%	20%	-61%	39%	-81%
dissolved organic carbon	14%	-4%	-5%	8%	-14%	-37%	5%	-48%	5%	-46%	9%	-19%	5%	0%	0%	-15%	10%	-36%	29%	-46%
iron	45%	-21%	9%	-17%	-35%	17%	-53%	-95%	18%	-88%	0%	12%	0%	0%	-13%	8%	-12%	-71%	30%	-44%
lead	-72%	-69%	-63%	-47%	-51%	-73%	-42%	-96%	-44%	-96%	0%	0%	0%	19%	5%	6%	9%	-78%	0%	-85%
magnesium	76%	21%	21%	28%	65%	-33%	32%	-78%	32%	-72%	7%	3%	0%	0%	0%	-22%	9%	-72%	35%	-77%
manganese	-6%	-7%	-39%	27%	20%	27%	-61%	-97%	-47%	-96%	0%	8%	11%	0%	9%	6%	15%	-91%	39%	-94%
mercury	75%	156%	50%	37%	75%	107%	975%	40%	975%	40%	0%	-21%	0%	0%	17%	-32%	13%	-54%	39%	-45%
molybdenum	0%	-8%	0%	-8%	1,700%	2,054%	109,900%	9,131%	53,900%	5,438%	0%	0%	0%	-14%	-18%	-3%	39%	-33%	80%	29%
monomer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
naphthenic acids – labile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-87%	-86%	-78%	-72%
naphthenic acids – refractory	1%	76%	4%	6%	49%	74%	840%	118%	303%	3%	0%	0%	1%	-3%	3%	16%	15%	-18%	29%	-13%
naphthenic acids – total	1%	76%	4%	6%	49%	74%	840%	118%	303%	3%	0%	0%	1%	-3%	3%	16%	9%	-20%	23%	-13%
nickel	25%	105%	204%	1,471%	1,454%	290%	2,043%	-33%	650%	-74%	1%	0%	0%	-73%	16%	-49%	38%	-89%	45%	-73%
PAH group 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-72%	24%	4%	-27%	-43%	0%	-14%
PAH group 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-67%	27%	-2%	40%	38%	48%	8%
PAH group 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-67%	23%	18%	-89%	-83%	-100%	-40%
PAH group 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36%	26%	-90%	-93%	-67%	-79%
PAH group 6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	171%	-16%	36%	-25%
PAH group 7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-84%	-72%	-38%	-23%
PAH group 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-73%	-74%	-34%	-64%
PAH group 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-71%	26%	6%	8%	-23%	-20%	-31%
potassium	10%	0%	-14%	20%	40%	-29%	160%	-45%	70%	-65%	0%	0%	6%	0%	0%	3%	18%	-25%	81%	-53%
selenium	-31%	-13%	-21%	-28%	-52%	-66%	114%	-78%	62%	-84%	0%	0%	5%	0%	-7%	0%	13%	-14%	21%	-29%
silver	-50%	-64%	-50%	-48%	675%	-31%	250%	-83%	150%	-87%	0%	0%	0%	-5%	29%	8%	17%	-32%	67%	-46%
sodium	47%	34%	17%	88%	28%	0%	687%	78%	233%	-17%	0%	10%	7%	-3%	-4%	2%	44%	3%	56%	-24%
strontium	75%	36%	25%	19%	92%	-10%	292%	-10%	150%	-41%	0%	0%	0%	0%	5%	-5%	24%	-16%	58%	-48%
sulphate	9%	-29%	24%	100%	930%	1,171%	5,294%	474%	1,536%	159%	0%	0%	0%	-66%	10%	-4%	27%	-6%	42%	22%
sulphide	-64%	-23%	-61%	15%	-42%	-52%	-100%	-100%	-100%	-100%	0%	0%	0%	0%	13%	-18%	-100%	-100%	-100%	-100%
tainting potential	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-39%	-76%	1,508%	335%
total dissolved solids	61%	9%	16%	17%	56%	-35%	234%	-3%	111%	-41%	0%	0%	3%	-1%	3%	-27%	18%	-12%	56%	-48%
total nitrogen	-20%	-23%	-18%	-13%	-18%	29%	226%	26%	63%	-45%	0%	0%	0%	8%	0%	8%	58%	63%	25%	6%
total phenolics	-5%	-34%	10%	-17%	119%	-14%	-100%	-100%	-100%	-100%	0%	0%	-4%	0%	12%	19%	-	-100%	-100%	-100%
total phosphorus	-33%	39%	-39%	-32%	80%	34%	-13%	-83%	-25%	-86%	0%	0%	-3%	0%	10%	0%	33%	-78%	77%	-86%
toxicity- acute	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	46%	49%	-45%	-15%
toxicity- chronic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-37%	-35%	-65%	-53%
vanadium	0%	-11%	-8%	25%	72%	143%	1,289%	104%	511%	7%	0%	0%	3%	-3%	7%	0%	32%	10%	57%	-9%
zinc	12%	-40%	84%	13%	420%	233%	300%	-76%	180%	-82%	0%	0%	-2%	21%	18%	7%	20%	-42%	-4%	-58%

Table 17-4 Percent and Absolute Change in Concentrations Predicted for M0 Under Application Case (continued)

	Absolute Change from Pre-development										Absolute Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	0.005	-0.11	0	0.04	0.028	0.14	0.27	-0.6	0.097	-0.82	0.003	-0.01	0.001	0	0.003	0.1	0.07	-0.21	0.01	-0.43
ammonia	-0.02	-0.3	-0.029	0.3	-0.007	-0.9	-0.077	-2	-0.077	-2	-0.001	0.1	0.006	0	0.002	0	-0.0048	-0.87	-0.0039	-1.8
antimony	-0.00049	-0.0062	-0.00042	-0.0048	-0.00043	-0.0077	-0.00023	-0.0091	-0.00024	-0.0091	0	0	0	0	0.00002	-0.0005	0.00004	-0.0016	-0.00001	-0.0017
arsenic	-0.00029	-0.0045	-0.00023	-0.0034	0.00006	0.0034	0.00009	-0.0053	-0.00008	-0.0055	0	0	0	-0.0003	0.00006	0.0007	0.00006	-0.00054	0.00003	-0.00074
barium	0.019	0.05	0.011	0.23	0.049	-0.37	0	-0.54	0.01	-0.52	0.003	0.02	0.004	0.01	0	-0.18	0.002	-0.32	0.022	-0.63
beryllium	0	0	0	0.0001	0.0001	0.0008	0.0006	0.0006	0.0003	0.0004	0	0	0	0	0	0	0.0001	-0.0001	0.0001	-0.0003
boron	0.012	-0.04	0.007	0.1	0.025	-0.12	0.82	0.39	0.37	-0.08	0.001	0	0.001	0.07	0.006	-0.03	0.16	0	0.13	0.06
cadmium	-0.0001	-0.0052	-0.000086	-0.0049	-0.000054	-0.0054	0.00012	-0.0068	0.00007	-0.0069	0	-0.0001	0.000001	0	0.000012	0.0003	0.00003	-0.00044	0.00005	-0.00062
calcium	20	17	8	30	44	82	10	-68	14	-62	1	5	1	-1	4	10	6	-58	15	-98
chloride	5.6	9	1.6	8	1.3	-6	44	38	16	1	0.3	-3	0.3	0	-0.5	-1	18	10	8	-4
chromium	-0.00022	-0.0016	0.00002	0.0001	0.0015	0.088	0.0019	-0.0016	0.00053	-0.0031	0.00001	0	0	-0.0048	0.0003	0.016	0.0004	0.0001	0.0001	-0.0002
cobalt	-0.0001	-0.0015	-0.00007	-0.0007	0.00059	0.0065	0.00053	-0.0016	0.00008	-0.0022	0.00001	0	0	-0.0013	0.00011	0.001	0.00015	-0.00005	0.00009	-0.00067
copper	-0.00025	-0.0011	-0.00036	0.0003	0.0009	0.025	0.0008	-0.0042	0.0001	-0.005	0.00004	-0.0001	0	-0.0007	0.0002	0.003	0.0003	-0.0031	0.00031	-0.0052
dissolved organic carbon	3	-2	-1	4	-3	-19	1	-25	1	-24	2	-12	1	0	0	-6	2	-15	5	-24
iron	0.5	-2.5	0.1	-2	-0.38	2	-0.58	-11	0.2	-10	0	1	0	0	-0.11	1	-0.07	-1.4	0.3	-1.2
lead	-0.00031	-0.0048	-0.00027	-0.0033	-0.00022	-0.0051	-0.00018	-0.0067	-0.00019	-0.0067	0	0	0	0.0006	0.00001	0.0001	0.00002	-0.001	0	-0.0014
magnesium	6.9	12	1.9	16	5.9	-19	2.9	-45	2.9	-42	1	2	0	0	-11	1	-33	3.1	-54	
manganese	-0.006	-0.1	-0.039	0.4	0.02	0.4	-0.061	-1.5	-0.047	-1.4	0	0.1	0.006	0	0.01	0.005	-0.46	0.015	-1.1	
mercury	0.0000003	0.0000067	0.0000002	0.0000016	0.0000003	0.0000046	0.0000039	0.0000017	0.0000039	0.0000017	0	-0.000003	0	0	0.0000001	-0.0000041	0.0000005	-0.0000007	0.0000012	-0.0000005
molybdenum	0	-0.0001	0	-0.0001	0.0017	0.027	0.11	0.12	0.054	0.071	0	0	0	-0.0002	-0.0004	-0.001	0.031	-0.06	0.024	0.016
monomer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
naphthenic acids – labile	0	0	0	0	0	0	0.025	0.11	0.0084	0.045	0	0	0	0	0	0	-0.16	-0.67	-0.031	-0.12
naphthenic acids – refractory	0.01	2.6	0.03	0.2	0.33	2.5	5.6	4	2	0.1	0	0	0.01	-0.1	0.03	0.8	0.8	-1.6	0.6	-0.5
naphthenic acids – total	0.01	2.6	0.03	0.2	0.33	2.5	5.6	4	2	0.1	0	0	0.01	-0.1	0.03	0.8	0.5	-1.8	0.5	-0.5
nickel	0.00014	0.022	0.0011	0.31	0.0081	0.061	0.011	-0.007	0.0036	-0.016	0.00001	0	0	-0.87	0.0012	-0.078	0.0033	-0.12	0.0013	-0.014
PAH group 1	0	0	0	0.0048	0.0084	0.029	0.0011	0.002	0.0003	0.0006	0	0	0	-0.012	0.0016	0.001	-0.0004	-0.0015	0	-0.0001
PAH group 2	0	0	0	0.0082	0.014	0.053	0.014	0.022	0.0031	0.0041	0	0	0	-0.017	0.003	-0.001	0.004	0.006	0.001	0.0003
PAH group 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 4	0	0	0	0.014	0.032	0.13	0.0001	0.0008	0	0.0003	0	0	0	-0.028	0.006	0.02	-0.0008	-0.0039	-0.0001	-0.0002
PAH group 5	0	0	0	0	0.015	0.049	0.0002	0.0013	0.0001	0.0007	0	0	0	0	0.004	0.01	-0.0018	-0.017	-0.0002	-0.0027
PAH group 6	0	0	0	0	0	0	0.0046	0.0084	0.0015	0.0021	0	0	0	0	0	0	0.0029	-0.0016	0.0004	-0.0007
PAH group 7	0	0	0	0	0	0	0.001	0.0034	0.0005	0.0017	0	0	0	0	0	0	-0.0051	-0.0086	-0.0003	-0.0005
PAH group 8	0	0	0	0	0	0	0.0064	0.012	0.0023	0.0047	0	0	0	0	0	0	-0.018	-0.034	-0.0012	-0.0083
PAH group 9	0	0	0	0.0029	0.0063	0.017	0.0013	0.0027	0.0004	0.0011	0	0	0	-0.0071	0.0013	0.001	0.0001	-0.0008	-0.0001	-0.0005
potassium	0.1	0	-0.14	1.1	0.4	-1.6	1.6	-2.5	0.7	-3.6	0	0	0.05	0	0	0.1	0.4	-1	0.76	-2.1
selenium	-0.00009	-0.0004	-0.00006	-0.0009	-0.00015	-0.0021	0.00033	-0.0025	0.00018	-0.0027	0	0	0.00001	0	-0.00001	0	0.00007	-0.00011	0.00008	-0.00021
silver	-0.000002	-0.000064	-0.000002	-0.000048	0.000027	-0.000031	0.00001	-0.000083	0.000006	-0.000087	0	0	0	-0.000003	0.000007	0.000005	0.000002	-0.000008	0.000004	-0.000011
sodium	3.5	14	1.3	36	2.1	0	52	32	18	-7	0	5	0.6	-2	-0.4	1	18	2	9	-11
strontium	0.09	0.21	0.03	0.11	0.11	-0.06	0.35	-0.06	0.18	-0.24	0	0	0	0	0.01	-0.03	0.09	-0.1	0.11	-0.32
sulphate	0.3	-10	0.8	34	31	398	175	161	51	54	0	0	0	-130	3	-19	38	-13	16	16
sulphide	-0.0047	-0.011	-0.0045	0.007	-0.0031	-0.025	-0.0074	-0.048	-0.0074	-0.048	0	0	0	0	0.0005	-0.005	-0.0002	-0.036	-0.0002	-0.04
tainting potential	0	0	0	0	0	0	0.061	0.073	0.082	0.1	0	0	0	0	0	0	-0.039	-0.23	0.077	0.077
total dissolved solids	116	68	30	129	107	-268	446	-23	212	-315	0	0	6	-10	8	-183	96	-98	145	-426
total nitrogen	-0.18	-0.7	-0.17	-0.4	-0.17	0.9	2.1	0.8	0.58	-1.4	0	0	0	0.2	0	0.3	1.1	1.5	0.3	0.1
total phenolics	-0.0001	-0.01	0.0002	-0.005	0.0025	-0.004	-0.0021	-0.029	-0.0021	-0.029	0	0	-0.0001	0	0.0005	0.004	0	-0.005	-0.0001	-0.0073
total phosphorus	-0.02	0.15	-0.024	-0.12	0.049	0.13	-0.008	-0.32	-0.015	-0.32	0	0	-0.001	0	0.01	0	0.013	-0.22	0.02	-0.34
toxicity- acute	0	0	0	0	0	0	0.06	0.097	0.0042	0.011	0	0	0	0	0	0	0.019	0.032	-0.0034	-0.002
toxicity- chronic	0	0	0	0	0	0	0.045	0.097	0.0046	0.015	0	0	0	0	0	0	-0.026	-0.053	-0.0084	-0.017
vanadium	0	-0.0003	-0.00003	0.0007	0.00026	0.004	0.0046	0.0029	0.0018	0.0002	0	0	0.00001	-0.0001	0.00004	0	0.0012	0.0005	0.0008	-0.0003
zinc	0.0003	-0.018	0.0021	0.006	0.01	0.1	0.0075	-0.034	0.0045	-0.037	0	0	-0.0001	0.009	0.002	0.01	0.0017	-0.008	-0.0003	-0.011

Table 17-5 Percent and Absolute Change in Concentrations Predicted for JK Under Application Case

	Percent Change from Pre-development										Percent Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	14%	-6%	11%	0%	14%	-14%	46%	-17%	46%	-17%	7%	-5%	0%	0%	0%	0%	5%	-5%	8%	-5%
ammonia	-8%	-23%	37%	108%	35%	-15%	23%	-23%	25%	-15%	-48%	-23%	0%	0%	0%	0%	-7%	0%	-7%	-8%
antimony	13%	-32%	13%	-54%	21%	-52%	38%	-64%	38%	-64%	0%	0%	0%	0%	0%	0%	0%	-14%	0%	-14%
arsenic	0%	-30%	50%	70%	50%	-48%	81%	48%	81%	-61%	-33%	-21%	0%	0%	0%	0%	0%	-43%	4%	-7%
barium	0%	-17%	35%	39%	19%	-19%	15%	-19%	19%	-19%	-28%	-15%	3%	0%	0%	0%	-3%	-2%	-3%	-4%
beryllium	-	-	-	-	-	-	-	-	-	-	-	-100%	-	0%	-	0%	-	14%	-	33%
boron	0%	-8%	9%	5%	6%	-15%	155%	5%	155%	5%	-8%	-6%	0%	0%	0%	0%	20%	-22%	20%	-22%
cadmium	4%	-8%	22%	-23%	36%	0%	133%	-19%	133%	-19%	-19%	-8%	-1%	0%	0%	0%	13%	-5%	13%	-5%
calcium	5%	-9%	14%	-4%	5%	-3%	0%	-7%	0%	-7%	-5%	-8%	0%	0%	0%	0%	-5%	-3%	-5%	-3%
chloride	4%	-8%	12%	42%	4%	-13%	540%	471%	540%	471%	-7%	-8%	0%	0%	-4%	-5%	33%	-22%	33%	-22%
chromium	10%	-17%	36%	-17%	36%	-28%	48%	-33%	48%	-33%	-11%	0%	0%	0%	0%	1%	0%	-4%	9%	-10%
cobalt	0%	-11%	30%	17%	22%	-17%	43%	-6%	43%	-33%	-26%	7%	0%	0%	0%	0%	3%	-11%	6%	-8%
copper	4%	-11%	20%	42%	20%	-14%	27%	17%	25%	-19%	-7%	-6%	0%	0%	0%	0%	0%	-19%	0%	-3%
dissolved organic carbon	-6%	-14%	0%	-10%	-6%	-12%	0%	-14%	0%	-14%	-6%	-11%	0%	0%	0%	0%	0%	-2%	0%	-2%
iron	0%	13%	8%	20%	8%	13%	0%	-27%	0%	-27%	-14%	21%	0%	0%	0%	0%	-8%	-8%	-8%	-8%
lead	68%	-3%	63%	-3%	63%	-27%	47%	-42%	47%	-42%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-5%
magnesium	0%	-13%	9%	-3%	0%	-5%	0%	-8%	0%	-6%	-8%	-11%	0%	0%	0%	-2%	0%	-3%	0%	-3%
manganese	-7%	-17%	2%	56%	3%	-29%	-5%	-34%	-3%	-31%	-23%	-6%	0%	0%	0%	0%	-2%	-3%	0%	-3%
mercury	0%	3%	180%	654%	160%	343%	240%	490%	240%	490%	-67%	-76%	0%	0%	0%	0%	-6%	-33%	-6%	-33%
molybdenum	0%	0%	200%	5,456%	100%	278%	10,900%	11,011%	10,900%	10,344%	-50%	-68%	0%	0%	0%	0%	41%	-17%	47%	-22%
monomer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
naphthenic acids – labile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	82%	0%	82%	0%
naphthenic acids – refractory	3%	-3%	9%	3%	7%	-8%	64%	28%	64%	28%	0%	0%	0%	0%	0%	0%	10%	-23%	10%	-23%
naphthenic acids – total	3%	-3%	9%	3%	7%	-8%	94%	50%	94%	50%	0%	0%	0%	0%	0%	0%	18%	-18%	18%	-18%
nickel	-2%	-13%	47%	31%	28%	-19%	167%	-6%	150%	-19%	-24%	-7%	0%	0%	-1%	0%	23%	-6%	15%	-7%
PAH group 1	-	-	-	-	-	-	-	-	-	-	-100%	-100%	0%	0%	0%	0%	11%	17%	0%	19%
PAH group 2	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	0%	0%	17%	7%	18%	7%
PAH group 3	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PAH group 4	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	0%	0%	12%	10%	13%	12%
PAH group 5	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	0%	0%	37%	-13%	39%	-13%
PAH group 6	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	0%	0%	-11%	5%	-11%	5%
PAH group 7	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	0%	0%	41%	2%	41%	2%
PAH group 8	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	0%	0%	30%	-8%	30%	-8%
PAH group 9	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	0%	0%	0%	6%	-7%	6%
potassium	16%	-9%	40%	64%	35%	-9%	65%	-9%	65%	-6%	-14%	-7%	0%	0%	0%	0%	2%	2%	2%	2%
selenium	5%	0%	14%	-3%	14%	-10%	48%	-16%	48%	-16%	0%	0%	0%	0%	0%	0%	7%	-4%	7%	-4%
silver	0%	-25%	1,800%	2,900%	1,600%	1,829%	1,600%	1,686%	1,600%	1,686%	-95%	-95%	0%	0%	0%	0%	-6%	19%	0%	19%
sodium	-6%	-13%	14%	179%	11%	53%	97%	121%	111%	124%	-25%	-27%	0%	0%	0%	0%	8%	-19%	15%	-20%
strontium	8%	0%	0%	59%	0%	0%	15%	-4%	15%	-4%	0%	0%	0%	0%	0%	1%	7%	-3%	7%	-3%
sulphate	20%	3%	40%	332%	18%	26%	175%	321%	150%	118%	0%	0%	0%	0%	0%	0%	16%	-11%	12%	-17%
sulphide	28%	-4%	9%	136%	16%	-12%	-9%	-16%	-9%	-16%	0%	0%	0%	0%	0%	0%	-15%	-42%	-15%	-42%
tainting potential	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	131%	47%	85%	11%
total dissolved solids	10%	-2%	14%	26%	7%	-4%	23%	7%	23%	8%	0%	0%	0%	0%	0%	-1%	5%	-18%	5%	-18%
total nitrogen	8%	-14%	14%	-11%	10%	-20%	25%	-26%	25%	-26%	0%	0%	0%	0%	0%	0%	2%	-4%	2%	-4%
total phenolics	25%	-3%	38%	17%	38%	-6%	4%	-17%	4%	-17%	0%	0%	0%	0%	0%	0%	-14%	-6%	-11%	-6%
total phosphorus	50%	12%	47%	218%	30%	53%	27%	47%	27%	24%	0%	0%	0%	0%	0%	0%	0%	-29%	0%	-5%
toxicity- acute	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0%	-69%	0%	-69%
toxicity- chronic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36%	0%	36%	0%
vanadium	24%	-13%	34%	-39%	28%	-41%	166%	-36%	166%	-36%	0%	0%	0%	0%	0%	0%	22%	-19%	22%	-20%
zinc	7%	-12%	2%	-21%	-2%	-39%	3%	-48%	2%	-54%	0%	0%	0%	-1%	2%	0%	-3%	-15%	-3%	-10%

Table 17-5 Percent and Absolute Change in Concentrations Predicted for JK Under Application Case (continued)

	Absolute Change from Pre-development										Absolute Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	0.004	-0.06	0.003	0	0.004	-0.14	0.013	-0.17	0.013	-0.17	0.002	-0.05	0	0	0	0	0.002	-0.04	0.003	-0.04
ammonia	-0.004	-0.3	0.019	1.4	0.018	-0.2	0.012	-0.3	0.013	-0.2	-0.044	-0.3	0	0	0	0	-0.005	0	-0.005	-0.1
antimony	0.00003	-0.0028	0.00003	-0.0047	0.00005	-0.0045	0.00009	-0.0056	0.00009	-0.0056	0	0	0	0	0	0	0	-0.0005	0	-0.0005
arsenic	0	-0.001	0.00008	0.0023	0.00008	-0.0016	0.00013	0.0016	0.00013	-0.002	-0.00008	-0.0006	0	0	0	0	0	-0.0037	0.00001	-0.0001
barium	0	-0.09	0.009	0.21	0.005	-0.1	0.004	-0.1	0.005	-0.1	-0.01	-0.08	0.001	0	0	0	-0.001	-0.01	-0.001	-0.02
beryllium	0	0	0	0.0015	0	0.0008	0.0001	0.0008	0.00005	0.0008	0	-0.0007	0	0	0	0	0.0001	0.0001	0.00005	0.0002
boron	0	-0.05	0.004	0.03	0.003	-0.1	0.073	0.03	0.073	0.03	-0.004	-0.04	0	0	0	0	0.02	-0.19	0.02	-0.19
cadmium	0.000003	-0.0002	0.000016	-0.0006	0.000026	0	0.000097	-0.0005	0.000097	-0.0005	-0.000018	-0.0002	-0.000001	0	0	0	0.00002	-0.0001	0.00002	-0.0001
calcium	2	-14	5	-6	2	-5	0	-11	0	-11	-2	-13	0	0	0	0	-2	-5	-2	-5
chloride	0.1	-2	0.3	10	0.1	-3	14	113	14	113	-0.2	-2	0	0	-0.1	-1	4	-39	4	-39
chromium	0.00008	-0.002	0.00029	-0.002	0.00029	-0.0034	0.00039	-0.004	0.00039	-0.0039	-0.00011	0	0	0	0	0.0001	0	-0.0003	0.0001	-0.0009
cobalt	0	-0.0002	0.00007	0.0003	0.00005	-0.0003	0.0001	-0.0001	0.0001	-0.0006	-0.00008	0.0001	0	0	0	0	0.00001	-0.0002	0.00002	-0.0001
copper	0.00002	-0.0004	0.0001	0.0015	0.0001	-0.0005	0.00014	0.0006	0.00013	-0.0007	-0.00004	-0.0002	0	0	0	0	0	-0.001	0	-0.0001
dissolved organic carbon	-1	-8	0	-6	-1	-7	0	-8	0	-8	-1	-6	0	0	0	0	0	-1	0	-1
iron	0	2	0.1	3	0.1	2	0	-4	0	-4	-0.2	3	0	0	0	0	-0.1	-1	-0.1	-1
lead	0.00013	-0.0001	0.00012	-0.0001	0.00012	-0.0009	0.00009	-0.0014	0.00009	-0.0014	0	0	0	0	0	0	0	0	0	-0.0001
magnesium	0	-8	1	-2	0	-3	0	-5	0	-4	-1	-7	0	0	0	-1	0	-2	0	-2
manganese	-0.004	-0.16	0.001	0.54	0.002	-0.28	-0.003	-0.33	-0.002	-0.3	-0.016	-0.05	0	0	0	0	-0.001	-0.02	0	-0.02
mercury	0	0.0000002	0.0000009	0.00004	0.0000008	0.000021	0.0000012	0.00003	0.0000012	0.00003	-0.000001	-0.00002	0	0	0	0	-0.0000001	-0.000018	-0.0000001	-0.000018
molybdenum	0	0	0.0002	0.049	0.0001	0.0025	0.011	0.099	0.011	0.093	-0.0001	-0.0019	0	0	0	0	0.0032	-0.02	0.0035	-0.026
monomer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
naphthenic acids – labile	0	0	0	0	0	0	0.2	1.2	0.2	1.2	0	0	0	0	0	0	0.09	0	0.09	0
naphthenic acids – refractory	0.02	-0.1	0.06	0.1	0.05	-0.3	0.43	1	0.43	1	0	0	0	0	0	0	0.1	-1.4	0.1	-1.4
naphthenic acids – total	0.02	-0.1	0.06	0.1	0.05	-0.3	0.63	1.8	0.63	1.8	0	0	0	0	0	0	0.2	-1.2	0.2	-1.2
nickel	-0.00001	-0.002	0.00028	0.005	0.00017	-0.003	0.001	-0.001	0.0009	-0.003	-0.00019	-0.001	0	0	-0.00001	0	0.0003	-0.001	0.0002	-0.001
PAH group 1	0	0	0.001	0.042	0.0008	0.027	0.001	0.027	0.0009	0.025	-0.001	-0.022	0	0	0	0	0.0001	0.004	0	0.004
PAH group 2	0.0016	0.15	0.0018	0.35	0.0014	0.16	0.0021	0.16	0.002	0.16	0	0	0	0	0	0	0.0003	0.01	0.0003	0.01
PAH group 3	0.0004	0.03	0.0003	0.06	0.0003	0.031	0.0003	0.019	0.0003	0.019	0	0	0	0	0	0	0	0	0	0
PAH group 4	0.0013	0.1	0.0017	0.33	0.0011	0.12	0.0019	0.11	0.0017	0.11	0	0	0	0	0	0	0.0002	0.01	0.0002	0.012
PAH group 5	0.0033	1.1	0.0031	3.3	0.0032	1.2	0.01	0.72	0.01	0.72	0	0	0	0	0	0	0.0027	-0.11	0.0028	-0.11
PAH group 6	0.001	0.061	0.0009	0.14	0.0008	0.069	0.0008	0.058	0.0008	0.058	0	0	0	0	0	0	-0.0001	0.003	-0.0001	0.003
PAH group 7	0.0021	0.63	0.0019	0.8	0.0019	0.64	0.0052	0.45	0.0052	0.45	0	0	0	0	0	0	0.0015	0.01	0.0015	0.01
PAH group 8	0.0029	1.4	0.0024	3	0.0027	1.5	0.0086	1.1	0.0086	1.1	0	0	0	0	0	0	0.002	-0.1	0.002	-0.1
PAH group 9	0.0015	0.12	0.0016	0.28	0.0014	0.12	0.0014	0.094	0.0013	0.094	0	0	0	0	0	0	0	0.005	-0.0001	0.005
potassium	0.09	-0.4	0.23	3	0.2	-0.4	0.37	-0.4	0.37	-0.3	-0.11	-0.3	0	0	0	0	0.02	0.1	0.02	0.1
selenium	0.00001	0	0.00003	-0.0001	0.00003	-0.0003	0.0001	-0.0005	0.0001	-0.0005	0	0	0	0	0	0	0.00002	-0.0001	0.00002	-0.0001
silver	0	-0.000007	0.000018	0.00081	0.000016	0.00051	0.000016	0.00047	0.000016	0.00047	-0.000019	-0.00042	0	0	0	0	-0.000001	0.00008	0	0.00008
sodium	-0.4	-5	1	68	0.8	20	6.9	46	7.9	47	-2.2	-12	0	0	0	0	1	-20	2	-21
strontium	0.01	0	0	0.41	0	0	0.02	-0.03	0.02	-0.03	0	0	0	0	0	0.01	0.01	-0.02	0.01	-0.02
sulphate	0.8	1	1.6	113	0.7	9	7	109	6	40	0	0	0	0	0	0	1.5	-17	1.1	-15
sulphide	0.0009	-0.001	0.0003	0.034	0.0005	-0.003	-0.0003	-0.004	-0.0003	-0.004	0	0	0	0	0	0	-0.0005	-0.015	-0.0005	-0.015
tainting potential	0	0	0	0	0	0	0.012	0.11	0.012	0.11	0	0	0	0	0	0	0.0068	0.035	0.0055	0.011
total dissolved solids	20	-13	27	166	14	-22	46	46	46	52	0	0	0	1	-1	-5	11	-149	11	-145
total nitrogen	0.06	-0.5	0.11	-0.4	0.08	-0.7	0.2	-0.9	0.2	-0.9	0	0	0	0	0	0	0.02	-0.1	0.02	-0.1
total phenolics	0.0006	-0.001	0.0009	0.006	0.0009	-0.002	0.0001	-0.006	0.0001	-0.006	0	0	0	0	0	0	-0.0004	-0.002	-0.0003	-0.002
total phosphorus	0.015	0.02	0.014	0.37	0.009	0.09	0.008	0.08	0.008	0.04	0	0	0	0	0	0	0	-0.1	0	-0.01
toxicity- acute	0	0	0	0	0	0	0.0041	0.027	0.0041	0.027	0	0	0	0	0	0	0	-0.059	0	-0.059
toxicity- chronic	0	0	0	0	0	0	0.038	0.31	0.038	0.31	0	0	0	0	0	0	0.01	0	0.01	0
vanadium	0.00007	-0.0008	0.0001	-0.0024	0.00008	-0.0025	0.00048	-0.0022	0.00048	-0.0022	0	0	0	0	0	0	0.00014	-0.0009	0.00014	-0.001
zinc	0.0004	-0.012	0.0001	-0.021	-0.0001	-0.039	0.0002	-0.048	0.0001	-0.054	0	0	0	-0.001	0.0001	0	-0.0002	-0.009	-0.0002	-0.005

Table 17-6 Percent and Absolute Change in Concentrations Predicted for KL Under Application Case

	Percent Change from Pre-development										Percent Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	-39%	39%	-4%	-6%	0%	-2%	10%	-71%	10%	-71%	-39%	48%	-26%	59%	-33%	71%	-15%	-26%	-8%	-26%
ammonia	-95%	-73%	-98%	-88%	-98%	-89%	-99%	-98%	-99%	-98%	-94%	-73%	67%	81%	133%	174%	100%	11%	67%	-8%
antimony	-7%	-15%	-21%	-28%	-29%	-33%	0%	-67%	7%	-63%	0%	0%	-27%	30%	-17%	57%	40%	0%	15%	-13%
arsenic	-51%	-4%	-48%	-37%	-59%	-39%	-17%	-63%	11%	-47%	-37%	36%	-45%	3%	-23%	63%	25%	-10%	-9%	-37%
barium	-51%	-47%	-51%	-63%	-63%	-65%	16%	-44%	29%	-35%	-36%	-25%	-42%	-35%	-21%	-13%	-14%	-27%	-20%	-39%
beryllium	-	-	-	-	-	-	-	-	-	-	-	-	-	0%	-	0%	100%	50%	100%	100%
boron	-38%	30%	-21%	-9%	-20%	-6%	520%	158%	410%	112%	-35%	39%	-21%	36%	-20%	63%	107%	47%	325%	250%
cadmium	-45%	-4%	-35%	-46%	-43%	-46%	206%	-32%	186%	-32%	-33%	50%	-30%	7%	-15%	60%	72%	19%	122%	27%
calcium	-26%	-23%	-29%	-34%	-35%	-34%	-3%	-9%	6%	-9%	-18%	-15%	-21%	-13%	-9%	-13%	-32%	-19%	-31%	-32%
chloride	-35%	-42%	-35%	-61%	-42%	-65%	2,977%	1,043%	2,323%	808%	-23%	-12%	-29%	-14%	-21%	-6%	150%	70%	1,300%	1,291%
chromium	-55%	-44%	-52%	-63%	-62%	-68%	-38%	-71%	-14%	-53%	-41%	-15%	-46%	-28%	-21%	19%	-22%	-38%	-31%	-48%
cobalt	-56%	-39%	-56%	-56%	-67%	-61%	51%	14%	51%	14%	-41%	-11%	-49%	-21%	-20%	23%	22%	0%	18%	-6%
copper	-12%	24%	-11%	-12%	-10%	-12%	27%	-32%	18%	-36%	-12%	35%	-18%	29%	-18%	29%	8%	-19%	18%	-6%
dissolved organic carbon	-19%	-23%	-19%	-33%	-23%	-35%	4%	-21%	4%	-19%	-9%	-18%	-9%	-15%	-5%	-10%	8%	-13%	4%	-19%
iron	-17%	-27%	-15%	-52%	-20%	-63%	-30%	-71%	-9%	-71%	-17%	3%	-23%	5%	-11%	29%	-42%	-7%	-39%	-39%
lead	-19%	-21%	-41%	-38%	-48%	-45%	-46%	-81%	-25%	-72%	0%	0%	-41%	6%	-16%	52%	-28%	-39%	-33%	-58%
magnesium	-25%	-29%	-30%	-42%	-36%	-44%	0%	-29%	10%	-24%	-16%	-20%	-20%	-11%	-9%	-4%	-17%	-33%	-15%	-38%
manganese	-29%	-4%	-28%	-32%	-37%	-32%	13%	-20%	24%	-16%	-18%	26%	-26%	-11%	-6%	-6%	-31%	-5%	-37%	-19%
mercury	-20%	42%	-20%	-8%	-20%	-8%	80%	25%	60%	8%	-20%	55%	-20%	57%	-20%	38%	80%	36%	167%	86%
molybdenum	0%	17%	0%	-17%	100%	33%	54,900%	26,567%	44,900%	19,900%	0%	17%	0%	25%	-60%	-43%	144%	70%	29,900%	23,900%
monomer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
naphthenic acids – labile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,111%	706%	35,900%	41,900%
naphthenic acids – refractory	-3%	-8%	-16%	-15%	-14%	-15%	270%	254%	204%	192%	0%	0%	-13%	10%	-11%	10%	89%	31%	180%	171%
naphthenic acids – total	-3%	-8%	-16%	-15%	-14%	-15%	270%	254%	204%	192%	0%	0%	-13%	10%	-11%	10%	89%	31%	180%	171%
nickel	-25%	39%	-12%	-7%	-4%	-4%	410%	37%	320%	13%	-25%	42%	-20%	30%	-26%	26%	13%	-13%	45%	33%
PAH group 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0%	0%	160%	238%	-	-
PAH group 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-67%	-33%	242%	262%	-	12,900%
PAH group 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0%	-14%	0%	26%	-	-
PAH group 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-20%	767%	547%	-	-
PAH group 6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	337%	295%	-	-
PAH group 7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	667%	567%	-	-
PAH group 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	593%	431%	-	-
PAH group 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-100%	0%	440%	455%	-	-
potassium	-37%	-45%	-38%	-50%	-48%	-50%	175%	109%	150%	82%	-24%	-33%	-25%	-15%	-9%	0%	57%	24%	88%	60%
selenium	-2%	-15%	-13%	-29%	-15%	-35%	34%	-34%	26%	-36%	0%	0%	-7%	23%	-5%	33%	29%	4%	31%	9%
silver	-38%	66%	-38%	106%	-38%	103%	425%	244%	375%	244%	-29%	71%	-44%	-20%	-38%	-22%	-48%	0%	-45%	0%
sodium	-53%	-35%	-52%	-52%	-63%	-57%	647%	570%	520%	461%	-35%	-12%	-45%	-31%	-18%	-9%	115%	51%	343%	258%
strontium	-9%	-23%	-22%	-36%	-25%	-36%	182%	86%	145%	59%	0%	0%	-14%	-13%	-10%	-13%	35%	8%	59%	40%
sulphate	-6%	-9%	-17%	-15%	2%	-9%	785%	473%	573%	355%	0%	0%	-14%	25%	-31%	-9%	77%	13%	438%	400%
sulphide	-27%	-23%	-100%	-96%	-100%	-97%	-100%	-99%	-100%	-99%	0%	0%	-	38%	-	129%	-	0%	-	0%
tainting potential	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,040%	900%	-	22,900%
total dissolved solids	-4%	-4%	-14%	-20%	-16%	-23%	176%	113%	139%	83%	0%	0%	-8%	4%	-9%	2%	48%	13%	87%	72%
total nitrogen	0%	0%	-9%	-27%	-9%	-27%	36%	0%	27%	-9%	0%	0%	0%	-6%	0%	0%	15%	-4%	27%	18%
total phenolics	2%	0%	-100%	-52%	-100%	-49%	-100%	-99%	-100%	-98%	0%	0%	-	138%	-	136%	-	-50%	-	-33%
total phosphorus	-3%	0%	-11%	-56%	-11%	-57%	16%	-61%	11%	-67%	0%	0%	-3%	25%	-11%	14%	-17%	-32%	-11%	-24%
toxicity- acute	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	700%	614%	-	-
toxicity- chronic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	953%	622%	-	51,900%
vanadium	-18%	-35%	-44%	-68%	-53%	-79%	413%	59%	349%	38%	0%	0%	-40%	-25%	-16%	18%	100%	51%	218%	155%
zinc	-17%	-24%	-49%	-38%	-62%	-40%	-28%	-64%	-6%	-43%	0%	0%	-46%	4%	-31%	39%	-19%	-44%	-26%	-51%

Table 17-6 Percent and Absolute Change in Concentrations Predicted for KL Under Application Case (continued)

	Absolute Change from Pre-development										Absolute Change from Base Case									
	2012		2033		2052		2065		Far Future		2012		2033		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	-0.039	0.19	-0.004	-0.03	0	-0.01	0.01	-0.35	0.01	-0.35	-0.039	0.22	-0.034	0.17	-0.05	0.2	-0.02	-0.05	-0.01	-0.05
ammonia	-0.095	-0.35	-0.098	-0.42	-0.098	-0.43	-0.099	-0.47	-0.099	-0.47	-0.077	-0.35	0.001	0.026	0.0012	0.033	0.0004	0.001	0.0004	-0.001
antimony	-0.0001	-0.0008	-0.0003	-0.0015	-0.0004	-0.0018	0	-0.0036	0.0001	-0.0034	0	0	-0.0004	0.0009	-0.0002	0.0013	0.0004	0	0.0002	-0.0003
arsenic	-0.00092	-0.0002	-0.00087	-0.0019	-0.0011	-0.002	-0.0003	-0.0032	0.0002	-0.0024	-0.00052	0.0013	-0.00077	0.0001	-0.00022	0.0012	0.0003	-0.0002	-0.0002	-0.0016
barium	-0.026	-0.061	-0.026	-0.082	-0.032	-0.084	0.008	-0.057	0.015	-0.045	-0.014	-0.023	-0.018	-0.026	-0.005	-0.007	-0.01	-0.027	-0.017	-0.055
beryllium	0	0	0	0.0001	0	0.0001	0.0002	0.0003	0.0002	0.0002	0	0	0	0	0	0	0.0001	0.0001	0.0001	0.0001
boron	-0.038	0.1	-0.021	-0.03	-0.02	-0.02	0.52	0.52	0.41	0.37	-0.033	0.12	-0.021	0.08	-0.02	0.12	0.32	0.27	0.39	0.5
cadmium	-0.00022	-0.0001	-0.00017	-0.0013	-0.00021	-0.0013	0.001	-0.0009	0.00091	-0.0009	-0.00013	0.0009	-0.00014	0.0001	-0.00005	0.00056	0.00063	0.0003	0.00077	0.0004
calcium	-8	-12	-9	-18	-11	-18	-1	-5	2	-5	-5	-7	-6	-5	-2	-5	-14	-11	-15	-23
chloride	-0.9	-4.1	-0.9	-6	-1.1	-6.4	77	102	60	79	-0.5	-0.8	-0.7	-0.6	-0.4	-0.2	48	46	58	83
chromium	-0.0016	-0.0034	-0.0015	-0.0049	-0.0018	-0.0053	-0.0011	-0.0055	-0.0004	-0.0041	-0.0009	-0.0008	-0.0012	-0.0011	-0.0003	0.0004	-0.0005	-0.0014	-0.0011	-0.0034
cobalt	-0.00041	-0.00055	-0.00041	-0.00078	-0.00049	-0.00086	0.00037	0.0002	0.00037	0.0002	-0.00022	-0.0001	-0.00031	-0.00016	-0.00006	0.0001	0.0002	0	0.00017	-0.0001
copper	-0.00013	0.0006	-0.00012	-0.0003	-0.00011	-0.0003	0.0003	-0.0008	0.0002	-0.0009	-0.00013	0.0008	-0.00022	0.0005	-0.00021	0.0005	0.0001	-0.0004	0.0002	-0.0001
dissolved organic carbon	-5	-10	-5	-14	-6	-15	1	-9	1	-8	-2	-7	-2	-5	-1	-3	2	-5	1	-8
iron	-0.17	-1.3	-0.15	-2.5	-0.2	-3	-0.3	-3.4	-0.09	-3.4	-0.17	0.1	-0.25	0.1	-0.1	0.4	-0.5	-0.1	-0.59	-0.9
lead	-0.0003	-0.0012	-0.00065	-0.0022	-0.00076	-0.0026	-0.00073	-0.0047	-0.0004	-0.0042	0	0	-0.00065	0.0002	-0.00016	0.0011	-0.00033	-0.0007	-0.0006	-0.0022
magnesium	-2.5	-5	-3	-7.2	-3.6	-7.4	0	-5	1	-4	-1.4	-3	-1.8	-1.2	-0.6	-0.4	-2	-6	-2	-8
manganese	-0.028	-0.01	-0.027	-0.08	-0.036	-0.08	0.013	-0.05	0.023	-0.04	-0.015	0.05	-0.025	-0.02	-0.004	-0.01	-0.05	-0.01	-0.07	-0.05
mercury	-0.0000001	0.0000005	-0.0000001	-0.0000001	-0.0000001	-0.0000001	0.0000004	0.0000003	0.0000003	0.0000001	-0.0000001	0.0000006	-0.0000001	0.0000004	-0.0000001	0.0000003	0.0000004	0.0000004	0.0000005	0.0000006
molybdenum	0	0.0001	0	-0.0001	0.0002	0.0002	0.11	0.16	0.09	0.12	0	0.0001	0	0.0001	-0.0006	-0.0006	0.065	0.066	0.09	0.12
monomer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
naphthenic acids – labile	0	0	0	0	0	0	0.046	0.29	0.036	0.21	0	0	0	0	0	0	0.042	0.25	0.036	0.21
naphthenic acids – refractory	-0.03	-0.1	-0.15	-0.2	-0.13	-0.2	2.5	3.3	1.9	2.5	0	0	-0.11	0.1	-0.1	0.1	1.6	1.1	1.8	2.4
naphthenic acids – total	-0.03	-0.1	-0.15	-0.2	-0.13	-0.2	2.5	3.3	1.9	2.5	0	0	-0.11	0.1	-0.1	0.1	1.6	1.1	1.8	2.4
nickel	-0.00025	0.0018	-0.00012	-0.0003	-0.00004	-0.0002	0.0041	0.0017	0.0032	0.0006	-0.00025	0.0019	-0.00022	0.001	-0.00034	0.0009	0.0006	-0.0009	0.0013	0.0013
PAH group 1	0	0	0	0	0.0001	0.0002	0.0013	0.0027	0.001	0.0021	0	0	0	0	0	0	0.0008	0.0019	0.001	0.0021
PAH group 2	0	0	0	0	0.0001	0.0004	0.013	0.017	0.01	0.013	0	0	0	0	-0.0002	-0.0002	0.0092	0.012	0.01	0.013
PAH group 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 4	0	0	0	0	0.0001	0.0006	0.0003	0.0024	0.0001	0.0015	0	0	0	0	0	-0.0001	0	0.0005	0.0001	0.0015
PAH group 5	0	0	0	0	0	0.0002	0.0026	0.011	0.002	0.0087	0	0	0	0	-0.00005	0.0023	0.0093	0.002	0.0087	
PAH group 6	0	0	0	0	0	0	0.0083	0.015	0.0066	0.011	0	0	0	0	0	0.0064	0.011	0.0066	0.011	
PAH group 7	0	0	0	0	0	0	0.0023	0.01	0.0018	0.0077	0	0	0	0	0	0.002	0.0085	0.0018	0.0077	
PAH group 8	0	0	0	0	0	0	0.0097	0.017	0.0077	0.013	0	0	0	0	0	0.0083	0.014	0.0077	0.013	
PAH group 9	0	0	0	0	0	0.0001	0.0027	0.0061	0.0021	0.0049	0	0	0	0	-0.0001	0	0.0022	0.005	0.0021	0.0049
potassium	-0.44	-1	-0.45	-1.1	-0.57	-1.1	2.1	2.4	1.8	1.8	-0.24	-0.6	-0.25	-0.2	-0.06	0	1.2	0.9	1.4	1.5
selenium	-0.00001	-0.0002	-0.00006	-0.00038	-0.00007	-0.00046	0.00016	-0.00044	0.00012	-0.00047	0	0	-0.00003	0.00017	-0.00002	0.00021	0.00014	0.00003	0.00014	0.00007
silver	-0.000003	0.000021	-0.000003	0.000034	-0.000003	0.000033	0.000034	0.000078	0.00003	0.000078	-0.000002	0.000022	-0.000004	-0.000016	-0.000003	-0.000018	-0.000038	0	-0.000031	0
sodium	-7.9	-8	-7.8	-12	-9.5	-13	97	131	78	106	-3.9	-2	-5.8	-5	-1.2	-1	60	52	72	93
strontium	-0.01	-0.05	-0.024	-0.08	-0.028	-0.08	0.2	0.19	0.16	0.13	0	0	-0.014	-0.02	-0.009	-0.02	0.08	0.03	0.1	0.1
sulphate	-0.3	-1	-0.9	-1.6	0.1	-1	41	52	30	39	0	0	-0.7	1.9	-2.4	-1	20	7	28	40
sulphide	-0.004	-0.006	-0.015	-0.025	-0.015	-0.025	-0.015	-0.026	-0.015	-0.026	0	0	0	0.0003	0	0.00045	0	0	0	0
tainting potential	0	0	0	0	0	0	0.0057	0.03	0.0045	0.023	0	0	0	0	0	0	0.0052	0.027	0.0045	0.023
total dissolved solids	-6	-11	-24	-58	-27	-65	295	323	233	237	0	0	-12	9	-14	4	151	69	186	219
total nitrogen	0	0	-0.1	-0.6	-0.1	-0.6	0.4	0	0.3	-0.2	0	0	0	-0.1	0	0	0.2	-0.1	0.3	0.3
total phenolics	0.0001	0	-0.0045	-0.0068	-0.0045	-0.0064	-0.0045	-0.013	-0.0045	-0.013	0	0	0	0.0036	0	0.0038	0	-0.0001	0	-0.0001
total phosphorus	-0.001	0	-0.004	-0.084	-0.004	-0.085	0.006	-0.092	0.004	-0.1	0	0	-0.001	0.013	-0.004	0.008	-0.009	-0.027	-0.005	-0.016
toxicity- acute	0	0	0	0	0	0	0.0064	0.015	0.005	0.011	0	0	0	0	0	0	0.0056	0.013	0.005	0.011
toxicity- chronic	0	0	0	0	0	0	0.02	0.07	0.016	0.052	0	0	0	0	0	0	0.018	0.06	0.016	0.052
vanadium	-0.00014	-0.0013	-0.00034	-0.0025	-0.00041	-0.0029	0.0032	0.0022	0.0027	0.0014	0	0	-0.00029	-0.0004	-0.00007	0.00012	0.002	0.002	0.0024	0.0031
zinc	-0.003	-0.01	-0.0088	-0.016	-0.011	-0.017	-0.005	-0.027	-0.001	-0.018	0	0	-0.0078	0.001	-0.0031	0.007	-0.003	-0.012	-0.006	-0.025

Table 17-8 Percent and Absolute Change in Concentrations Predicted at the Mouth of the Muskeg River Under Application Case

Parameter	Percent Change from Pre-development										Percent Change from Base Case									
	2012		2032		2052		2065		Far Future		2012		2032		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
ammonia	5%	-23%	9%	-35%	2%	-57%	2%	-60%	4%	-56%	-2%	-15%	3%	-14%	-2%	-22%	-1%	-25%	-1%	-24%
antimony	0%	-13%	0%	-17%	0%	-17%	5%	-17%	5%	-17%	0%	-2%	0%	-1%	-4%	-1%	0%	0%	-2%	-1%
arsenic	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
barium	0%	-20%	0%	-26%	0%	-27%	0%	-27%	0%	-27%	-1%	-10%	0%	-4%	0%	0%	0%	0%	0%	0%
beryllium	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
boron	3%	-10%	11%	-16%	11%	-31%	97%	103%	67%	46%	0%	-1%	3%	2%	-5%	-10%	15%	36%	15%	34%
cadmium	0%	0%	0%	0%	0%	0%	2%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
calcium	3%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
chloride	0%	0%	0%	0%	0%	2%	19%	8%	13%	4%	0%	0%	0%	0%	0%	2%	12%	6%	13%	4%
chromium	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
cobalt	1%	0%	1%	0%	0%	0%	2%	0%	1%	0%	0%	0%	0%	0%	-1%	0%	0%	0%	-1%	0%
copper	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
dissolved organic carbon	0%	0%	0%	0%	-10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-10%	0%	0%	0%	0%	0%
iron	-1%	0%	-3%	0%	-5%	0%	-6%	0%	-1%	0%	0%	0%	0%	0%	-1%	0%	-1%	0%	1%	0%
lead	-1%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
magnesium	0%	-5%	0%	-21%	-11%	-21%	0%	-21%	0%	-21%	0%	0%	0%	0%	-11%	0%	0%	0%	0%	0%
manganese	7%	-2%	7%	-6%	-4%	-6%	-2%	-6%	2%	-6%	-4%	-2%	2%	-2%	-4%	0%	0%	0%	0%	0%
mercury	1%	0%	1%	0%	1%	0%	3%	0%	1%	0%	0%	0%	1%	0%	0%	0%	2%	0%	1%	0%
molybdenum	14%	1%	36%	1%	50%	1%	379%	286%	264%	147%	0%	0%	0%	0%	-19%	-2%	40%	63%	38%	89%
monomer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
naphthenic acids – labile	-	-	-	-	-	-	-	-	-	-	-	0%	-	0%	-	0%	-	-27%	-	0%
naphthenic acids – refractory	11%	0%	16%	-4%	11%	-3%	126%	57%	79%	14%	0%	-1%	5%	-1%	-9%	-1%	13%	33%	17%	11%
naphthenic acids	16%	0%	32%	-2%	26%	-1%	142%	63%	105%	19%	0%	-1%	4%	-1%	-8%	-1%	12%	29%	15%	13%
nickel	2%	1%	10%	134%	10%	156%	13%	131%	2%	1%	0%	0%	0%	-2%	0%	11%	-47%	-29%	0%	1%
PAH group 1 (carc)	-	-	-	-	-	-	-	-	-	-	-	0%	-	0%	-	0%	-	0%	-	-
PAH group 2 (carc)	-	-	-	-	-	-	-	-	-	-	-	0%	-	50%	-	50%	-	67%	-	200%
PAH group 3 (carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 4 (non-carc)	-	-	-	-	-	-	-	-	-	-	0%	-25%	-	25%	-	67%	-	0%	-	-
PAH group 5 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-50%	-	-25%	-	50%	-	-33%	-	100%
PAH group 6 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 7 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 8 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 9 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	0%	-	0%	-	0%	-	0%	-	-
potassium	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
selenium	0%	-1%	0%	-1%	0%	-1%	5%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	1%
silver	0%	-2%	6%	0%	0%	-2%	6%	-2%	6%	-2%	-5%	0%	0%	0%	-22%	-1%	0%	0%	0%	0%
sodium	0%	-2%	0%	-2%	0%	0%	18%	7%	12%	2%	0%	0%	0%	-2%	0%	0%	5%	4%	6%	0%
strontium	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
sulphate	0%	0%	0%	0%	0%	0%	8%	6%	0%	0%	0%	0%	0%	0%	0%	0%	4%	6%	0%	0%
sulphide	0%	-21%	0%	-21%	0%	-36%	-25%	-36%	-25%	-36%	0%	-15%	0%	0%	0%	-10%	0%	-10%	0%	-10%
tainting potential	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	-62%	-13%	76%	92%	122%	9%
total dissolved solids	1%	0%	0%	-3%	-1%	-3%	9%	11%	6%	-1%	0%	0%	0%	0%	-1%	-1%	3%	7%	4%	2%
total nitrogen	0%	0%	0%	0%	0%	0%	14%	0%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%	14%	0%
total phenolics	0%	-2%	0%	-2%	-3%	-1%	-3%	-2%	-3%	-3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
total phosphorus	3%	0%	3%	0%	0%	0%	3%	0%	0%	0%	0%	0%	2%	0%	-2%	0%	2%	0%	0%	0%
toxicity – acute	-	-	-	-	-	-	-	-	-	-	-	0%	-	0%	-	-38%	-	115%	-	0%
toxicity – chronic	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	-20%	-4%	0%	25%	0%	0%
vanadium	0%	0%	0%	0%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
zinc	0%	0%	0%	0%	0%	0%	0%	-3%	0%	-3%	0%	0%	0%	0%	0%	2%	0%	-2%	0%	-2%

Table 17-8 Percent and Absolute Change in Concentrations Predicted at the Mouth of the Muskeg River Under Application Case (continued)

Parameter	Absolute Change from Pre-development										Absolute Change from Base Case									
	2012		2032		2052		2065		Far Future		2012		2032		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0.01	0	0	0
ammonia	0.0015	-0.079	0.0026	-0.12	0.0007	-0.2	0.0006	-0.21	0.001	-0.19	-0.0007	-0.049	0.0008	-0.037	-0.0005	-0.041	-0.0003	-0.047	-0.0004	-0.048
antimony	0	-0.00023	0	-0.0003	0	-0.0003	0.00002	-0.0003	0.00002	-0.00029	0	-0.00003	0	-0.00002	-0.00002	-0.00002	0	0	-0.00001	-0.00001
arsenic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
barium	0	-0.028	0	-0.037	0	-0.038	0	-0.038	0	-0.038	-0.001	-0.013	0	-0.004	0	0	0	0	0	0
beryllium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
boron	0.001	-0.016	0.004	-0.024	0.004	-0.047	0.035	0.16	0.024	0.071	0	-0.001	0.001	0.003	-0.002	-0.012	0.009	0.083	0.008	0.057
cadmium	0	-0.00001	0	-0.00001	0	-0.00001	0.00001	0	0.00001	0	0	0	0	0	0	0	0	0	0	0
calcium	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
chloride	0	0	0	0	0	1	3	4	2	2	0	0	0	0	0	1	2	3	2	2
chromium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cobalt	0.00001	0	0.00001	0	0	0	0.00002	0	0.00001	0	0	0	0	0	-0.00001	0	0	0	-0.00001	0
copper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dissolved organic carbon	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0
iron	-0.01	0	-0.03	0	-0.05	0	-0.06	0	-0.01	0	0	0	0	0	-0.01	0	-0.01	0	0.01	0
lead	-0.00001	-0.00001	0	-0.00001	0	0	0	0	-0.00001	0	0	0	0	0	0	0	0	0	-0.00001	0
magnesium	0	-1	0	-4	-1	-4	0	-4	0	0	0	0	0	0	-1	0	0	0	0	0
manganese	0.003	-0.006	0.003	-0.016	-0.002	-0.016	-0.001	-0.016	0.001	-0.016	-0.002	-0.006	0.001	-0.004	-0.002	0	0	0	0	0
mercury	0.0000001	-0.0000001	0.0000002	0	0.0000001	0	0.0000004	0	0.0000002	-0.0000003	0	0	0.0000001	0	0	0	0.0000003	0	0.0000001	0
molybdenum	0.0002	0.0001	0.0005	0.0001	0.0007	0.0001	0.0053	0.032	0.0037	0.016	0	0	0	0	-0.0005	-0.0002	0.0019	0.017	0.0014	0.013
monomer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
naphthenic acids – labile	0	0.03	0.02	0.08	0.02	0.09	0.03	0.11	0.04	0.17	0	0	0	0	0	0	0	-0.04	0.01	0
naphthenic acids – refractory	0.02	0	0.03	-0.05	0.02	-0.04	0.24	0.78	0.15	0.2	0	-0.01	0.01	-0.01	-0.02	-0.02	0.05	0.54	0.05	0.16
naphthenic acids	0.03	0	0.06	-0.03	0.05	-0.02	0.27	0.87	0.2	0.26	0	-0.01	0.01	-0.01	-0.02	-0.02	0.05	0.51	0.05	0.19
nickel	0.0001	0.0001	0.0005	0.023	0.0005	0.026	0.0007	0.022	0.0001	0.0001	0	0	0	-0.001	0	0.0042	-0.0053	-0.016	0	0.0001
PAH group 1 (carc)	-	-	-	-	-	-	-	-	-	-	-	0	-	0	-	0	-	0	-	-
PAH group 2 (carc)	-	-	-	-	-	-	-	-	-	-	-	0	-	0.001	-	0.001	-	0.002	-	0.002
PAH group 3 (carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 4 (non-carc)	-	-	-	-	-	-	-	-	-	-	0	-0.001	-	0.001	-	0.002	-	0	-	-
PAH group 5 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-0.001	-	-0.001	-	0.001	-	-0.001	-	0.001
PAH group 6 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.001	-	-	-
PAH group 7 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.001	-	0	-	0	-	0
PAH group 8 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.004	-	0	0	0.001	-	0.001
PAH group 9 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	0	-	0	-	0	-	0	-	-
potassium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
selenium	0	-0.00001	0	-0.00001	0	-0.00001	0.00001	0	0.00001	0	0	0	0	0	0	0	0	0	0.00001	0.00001
silver	0	-0.000003	0.000001	0	0	-0.000002	0.000001	-0.000003	0.000001	-0.000003	-0.000001	0	0	0	-0.000005	-0.000001	0	0	0	0
sodium	0	-1	0	-1	0	0	3	3	2	1	0	0	0	-1	0	0	1	2	1	0
strontium	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0.001	0	0	0
sulphate	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	1	3	0	0
sulphide	0	-0.003	0	-0.003	0	-0.005	-0.001	-0.005	-0.001	-0.005	0	-0.002	0	0	0	-0.001	0	-0.001	0	-0.001
tainting potential	-	-	-	-	-	-	-	-	-	-	0	0	0	0	-0.0023	-0.0037	0.0029	0.025	0.0028	0.004
total dissolved solids	2	1	0	-8	-1	-10	16	33	11	-2	0	0	0	0	-1	-2	5	23	8	6
total nitrogen	0	0	0	0	0	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0	0.1	0
total phenolics	0	-0.0005	0	-0.0005	-0.0001	-0.0003	-0.0001	-0.0005	-0.0001	-0.0006	0	0	0	0	0	0	0	0	0	0
total phosphorus	0.002	0	0.002	0	0	0	0.002	0	0	0	0	0	0.001	0	-0.001	0	0.001	0	0	0
toxicity – acute	-	-	-	-	-	-	-	-	-	-	-	0	0	0	-0.001	-0.003	0.001	0.015	0.001	0
toxicity – chronic	-	-	-	-	-	-	-	-	-	-	0	0	0	0	-0.001	-0.001	0	0.008	0	0
vanadium	0	0	0	0	0	0	0.0001	0	0	0	0	0	0	0	0	0	0	0	0	0
zinc	0	0	0	0	0	0	0	-0.002	0	-0.002	0	0	0	0	0	0.001	0	-0.001	0	-0.001

Table 17-9 Percent and Absolute Change in Concentrations Predicted at the Mouth of the Pierre River Under Application Case

Parameter	Percent Change from Pre-development										Percent Change from Base Case									
	2012		2032		2052		2065		Far Future		2012		2032		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	0%	0%	0%	0%	0%	0%	0%	-1%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%
ammonia	18%	36%	21%	40%	24%	43%	23%	40%	15%	25%	0%	0%	-1%	1%	-7%	-4%	-7%	-5%	-8%	-6%
antimony	0%	0%	0%	0%	4%	0%	4%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
arsenic	0%	0%	0%	0%	10%	0%	10%	0%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
barium	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	-1%	0%	-1%	0%
beryllium	0%	0%	0%	-2%	0%	-2%	0%	-2%	0%	-2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
boron	8%	0%	11%	1%	28%	8%	39%	17%	33%	13%	0%	0%	0%	-1%	-8%	-11%	0%	-1%	-2%	-5%
cadmium	0%	-1%	3%	-1%	5%	-1%	8%	-3%	8%	-4%	0%	0%	0%	0%	-5%	1%	-2%	-1%	-2%	-2%
calcium	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
chloride	0%	0%	0%	0%	10%	3%	10%	3%	10%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
chromium	3%	0%	3%	0%	3%	0%	3%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
cobalt	1%	0%	1%	0%	5%	0%	5%	0%	5%	0%	0%	0%	0%	0%	-3%	0%	-3%	0%	-4%	0%
copper	4%	0%	4%	0%	4%	0%	4%	0%	4%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%
dissolved organic carbon	0%	0%	0%	0%	11%	0%	11%	0%	11%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
iron	0%	0%	-3%	-1%	-3%	-1%	-2%	-1%	1%	-1%	0%	0%	-3%	0%	-4%	0%	-2%	-1%	0%	-1%
lead	0%	0%	0%	0%	7%	0%	8%	0%	8%	0%	0%	0%	0%	0%	-5%	0%	-3%	0%	-3%	0%
magnesium	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
manganese	0%	5%	0%	-7%	-3%	-8%	0%	-17%	11%	-15%	0%	1%	-3%	-13%	-3%	-12%	0%	-17%	11%	-19%
mercury	2%	0%	3%	-1%	3%	-1%	4%	-1%	5%	-1%	0%	0%	0%	0%	-1%	1%	1%	1%	4%	1%
molybdenum	64%	3%	86%	4%	107%	4%	136%	5%	86%	3%	0%	0%	0%	0%	-12%	-2%	0%	0%	-10%	-1%
monomer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
naphthenic acids – labile	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	-33%	-36%	-33%	-33%	-33%	-37%
naphthenic acids – refractory	10%	1%	10%	1%	50%	3%	70%	7%	60%	4%	0%	0%	0%	0%	-17%	-1%	-6%	1%	-11%	-1%
naphthenic acids	40%	3%	60%	4%	110%	13%	130%	14%	110%	13%	0%	0%	0%	0%	-16%	-20%	-8%	-17%	-13%	-18%
nickel	2%	0%	4%	0%	4%	-1%	4%	-1%	0%	-1%	0%	0%	0%	0%	0%	0%	-4%	-1%	-2%	0%
PAH group 1 (carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 2 (carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 3 (carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 4 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 5 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	0%	-	0%	-	0%	-	0%	-	0%
PAH group 6 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 7 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 8 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 9 (non-carc)	-	0%	-	0%	-	-	-	-	-	-	-	0%	-	0%	-	-	-	-	-	-
potassium	7%	0%	7%	-4%	7%	-4%	7%	0%	7%	0%	0%	0%	0%	-4%	-6%	-4%	-6%	0%	-6%	0%
selenium	0%	0%	0%	0%	0%	0%	5%	0%	5%	0%	0%	0%	0%	0%	-5%	0%	0%	0%	0%	0%
silver	0%	0%	0%	0%	6%	0%	6%	0%	11%	0%	0%	0%	0%	0%	0%	0%	0%	0%	11%	0%
sodium	0%	0%	0%	3%	7%	8%	7%	8%	7%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
strontium	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
sulphate	0%	0%	0%	3%	4%	3%	7%	3%	4%	2%	0%	0%	-4%	0%	0%	0%	4%	0%	0%	-2%
sulphide	33%	4%	0%	-52%	0%	-52%	0%	-52%	0%	-52%	33%	4%	-25%	-52%	0%	-52%	0%	-52%	0%	-52%
tainting potential	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	-33%	-39%	-28%	-37%	-33%	-41%
total dissolved solids	1%	0%	1%	1%	3%	4%	4%	4%	4%	4%	0%	0%	-1%	0%	-1%	-2%	0%	-2%	0%	-2%
total nitrogen	0%	0%	0%	0%	14%	0%	14%	0%	14%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
total phenolics	3%	-1%	3%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%	-3%	0%	-3%	1%	0%	1%
total phosphorus	0%	0%	0%	0%	2%	0%	3%	0%	3%	0%	0%	0%	0%	0%	0%	0%	2%	0%	2%	0%
toxicity – acute	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	-33%	-32%	0%	-30%	-33%	-35%
toxicity – chronic	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%	-21%	-26%	-14%	-25%	-30%	-38%
vanadium	32%	1%	32%	0%	32%	0%	36%	0%	5%	-1%	0%	0%	0%	-1%	-3%	0%	0%	0%	0%	-1%
zinc	0%	2%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-2%	0%	-2%

Table 17-9 Percent and Absolute Change in Concentrations Predicted at the Mouth of the Pierre River Under Application Case (continued)

Parameter	Absolute Change from Pre-development										Absolute Change from Base Case									
	2012		2032		2052		2065		Far Future		2012		2032		2052		2065		Far Future	
	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak	median	peak
aluminum	0	0	0	0	0	-0.01	0	-0.03	0	-0.03	0	0	0	0	0	0.01	0	-0.01	0	-0.02
ammonia	0.0056	0.054	0.0064	0.06	0.0072	0.064	0.0071	0.06	0.0045	0.038	0	0.0007	-0.0005	0.0022	-0.0028	-0.0095	-0.0029	-0.012	-0.0029	-0.013
antimony	0	0	0	0	0.00001	0	0.00001	0	0.00001	0	0	0	0	0	0	0	0	0	0	0
arsenic	0	0	0	0	0.0001	0	0.0001	0	0.0001	0	0	0	0	0	0	0	0	0	0	0
barium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.001	0	-0.001	0	-0.001	0
beryllium	0	0	0	-0.0001	0	-0.0001	0	-0.0001	0	-0.0001	0	0	0	0	0	0	0	0	0	0
boron	0.003	0	0.004	0.001	0.01	0.007	0.014	0.016	0.012	0.012	0	0	0	-0.001	-0.004	-0.012	0	-0.001	-0.001	-0.005
cadmium	0	-0.00005	0.00001	-0.00007	0.00002	-0.00013	0.00003	-0.00029	0.00003	-0.00036	0	0	0	0	-0.00002	0.00007	-0.00001	-0.00009	-0.00001	-0.00019
calcium	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
chloride	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
chromium	0.0001	0	0.0001	0	0.0001	0	0.0001	0	0.0001	0	0	0	0	0	0	0	0	0	0	0
cobalt	0.00001	-0.00001	0.00001	-0.00001	0.00006	0	0.00006	0	0.00005	0	0	0	0	0	-0.00004	0	-0.00004	0	-0.00005	0
copper	0.0001	0	0.0001	0	0.0001	0	0.0001	0	0.0001	-0.0001	0	0	0	0	0	0	0	0	0	-0.0001
dissolved organic carbon	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
iron	0	-0.01	-0.03	-0.05	-0.03	-0.07	-0.02	-0.1	0.01	-0.11	0	0	-0.03	-0.03	-0.04	-0.04	-0.02	-0.07	0	-0.08
lead	0	-0.00001	0	-0.00001	0.00007	-0.00001	0.00008	-0.00002	0.00008	-0.00002	0	0	0	0	-0.00006	-0.00001	-0.00004	-0.00002	-0.00004	-0.00002
magnesium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
manganese	0	0.014	0	-0.019	-0.001	-0.022	0	-0.049	0.004	-0.043	0	0.003	-0.001	-0.038	-0.001	-0.036	0	-0.049	0.004	-0.057
mercury	0.0000003	-0.0000007	0.0000004	-0.0000008	0.0000004	-0.0000017	0.0000006	-0.0000017	0.0000008	-0.0000019	0	0	0	0	-0.0000001	0.0000001	0.0000001	0.0000001	0.0000006	0.0000001
molybdenum	0.0009	0.0003	0.0012	0.0004	0.0015	0.0004	0.0019	0.0006	0.0012	0.0003	0	0	0	0	-0.0004	-0.0002	0	0	-0.0003	-0.0001
monomer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
naphthenic acids – labile	0.02	0.13	0.03	0.2	0.04	0.28	0.04	0.28	0.04	0.26	0	0	0	0	-0.02	-0.16	-0.02	-0.14	-0.02	-0.15
naphthenic acids – refractory	0.01	0.01	0.01	0.01	0.05	0.02	0.07	0.05	0.06	0.03	0	0	0	0	-0.03	-0.01	-0.01	0.01	-0.02	-0.01
naphthenic acids	0.04	0.02	0.06	0.03	0.11	0.09	0.13	0.1	0.11	0.09	0	0	0	0	-0.04	-0.2	-0.02	-0.16	-0.03	-0.17
nickel	0.0001	0	0.0002	0	0.0002	-0.0001	0.0002	-0.0001	0	-0.0001	0	0	0	0	0	0	-0.0002	-0.0001	-0.0001	0
PAH group 1 (carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 2 (carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 3 (carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 4 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-
PAH group 5 (non-carc)	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0
PAH group 6 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 7 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAH group 8 (non-carc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0	-	0
PAH group 9 (non-carc)	-	0	-	0	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-
potassium	0.1	0	0.1	-0.1	0.1	-0.1	0.1	0	0.1	0	0	0	0	-0.1	-0.1	-0.1	-0.1	0	-0.1	0
selenium	0	0	0	0	0	0	0.00001	0	0.00001	0	0	0	0	0	-0.00001	0	0	0	0	0
silver	0	0	0	0	0.000001	0	0.000001	0	0.000002	0	0	0	0	0	0	0	0	0	0.000002	0
sodium	0	0	0	1	1	3	1	3	1	3	0	0	0	0	0	0	0	0	0	0
strontium	0	0.001	0	0	0	-0.001	0	-0.001	-0.001	-0.002	0	0	0	-0.001	-0.001	0.001	-0.001	0.001	-0.002	0
sulphate	0	0	0	2	1	2	2	2	1	1	0	0	-1	0	0	0	1	0	0	-1
sulphide	0.001	0.001	0	-0.012	0	-0.012	0	-0.012	0	-0.012	0.001	0.001	-0.001	-0.012	0	-0.012	0	-0.012	0	-0.012
tainting potential	-	-	-	-	-	-	-	-	-	-	0	0	0	0	-0.0022	-0.05	-0.0019	-0.045	-0.0021	-0.048
total dissolved solids	2	1	2	3	5	11	7	13	7	12	0	0	-1	-1	-2	-7	0	-5	0	-5
total nitrogen	0	0	0	0	0.1	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0	0	0
total phenolics	0.0001	-0.0001	0.0001	0	0	-0.0001	0	0	0	0	0	0	0	0	-0.0001	0	-0.0001	0.0001	0	0.0001
total phosphorus	0	0	0	0	0.001	0	0.002	0	0.002	-0.001	0	0	0	0	0	0	0.001	0	0.001	-0.001
toxicity – acute	-	-	-	-	-	-	-	-	-	-	0	0	0	0	-0.001	-0.009	0	-0.008	-0.001	-0.009
toxicity – chronic	-	-	-	-	-	-	-	-	-	-	0	0	0	0	-0.003	-0.029	-0.002	-0.026	-0.003	-0.03
vanadium	0.0007	0.0001	0.0007	0	0.0007	0	0.0008	0	0.0001	-0.0001	0	0	0	-0.0001	-0.0001	0	0	0	0	-0.0001
zinc	0	0.001	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	-0.001	0	-0.001

18. Ratings system for constituents with guidelines unclear.

Request:

Provide additional rationale and clear criteria for the ratings system when guidelines are present. State whether the rating is provided against changes to the acute guideline, chronic guideline or both. Define “slightly”, “marginal” and “substantial” exceedances.

Response:

The lowest applicable guideline is applied to each constituent. Therefore, if a constituent has both a chronic and acute guideline, the chronic guideline is applied.

The terms “slightly”, “marginal” or “substantial” are not used to rate water quality guideline exceedances. Concentrations are either above guidelines or they are not, and the criteria listed in the EIA, Volume 4, Section 6.5.5.3, page 6-399 are applied without any subjective rating.

19. Pit lakes littoral zones too small.

Request:

Ensure that littoral zones for pit lakes are within the range of 20 to 30% and not on the lower end of the expected range (i.e., 10-15%).

Response:

The pit lakes are designed to support a viable aquatic ecosystem, with an active littoral zone within the lake area. The littoral zone will represent roughly 10 to 30% of the lake area and include shallow wetlands and shoreline habitat. These proportions are analogous to natural lakes in the region and are designed with the specific function of enhancing the productive capacity of these waterbodies. The proportion of littoral zone within each lake is dependant on its size, depth and other physical characteristics. The proportions presented in Shell’s closure drainage plan are appropriate for the closure landscape.

20. Impacts of pit lake discharge on traditional water use unclear.

Request:

- i. Identify how the pit lake release criteria will consider potential impacts on traditional use of water downstream and the consequent effects on Treaty and Aboriginal rights.**

Response:

- i. Shell's pit lake release criteria will ensure that there are no significant adverse environmental impacts to water quality and aquatic health. There will be some changes to water chemistry, but these will be of such limited extent that they will not manifest themselves in a tangible adverse impact to ACFN's ability to exercise Aboriginal Rights. Accordingly, to the extent ACFN's exercise of Aboriginal rights related to downstream water quality and aquatic health, there are no anticipated impacts to traditional use of water downstream, and no consequent effects on the exercise of Aboriginal rights. In terms of changes related to water quantity, potential impacts to ACFN's ability to exercise traditional activities will be mitigated through Shell's commitment to compensate for any lost fish habitat as part of Shell's No Net Loss Plan, in consultation with ACFN and other stakeholders.

Request:

- ii. Discuss the role of Fisheries and Oceans Canada (DFO) and other federal regulators in the selection of relevant release parameters and the process of permitting the reconnection of pit lakes to the watershed drainage system of the Athabasca River.**

Response:

- ii. DFO is responsible for the Fisheries Act which includes section 36(3) - a prohibition on the release of deleterious substances unless allowed under a regulation. Environment Canada has also been delegated authority under the Fisheries Act to enforce section 36(3). Environment Canada also administers the Migratory Birds Convention Act section 5.1(1) which prohibits the release of substances harmful to migratory birds in an area frequented by migratory birds. Both agencies would have a regulatory role in permitting the release of water from pit lakes to the natural environment. It is expected that water quality data would be reviewed and compared to background water quality and water quality guidelines to determine if it met the intent of the two acts. However, the actual process would be up to the regulators.

21. Pit lake sediment quality not modelled.

Request:

- i. Describe characterization of pit lake sediment at closure.**

Response:

- i. At Closure, the pit lakes will function as treatment waterbodies. They will not be expected to immediately behave as fully-functioning ecosystems. Over time, the Mature Fine Tailings (MFT) will consolidate and become covered with sediment and organic matter that be deposited due to natural processes. At this stage, field studies conducted on MFT-containing waterbodies provide a picture of how pit lake sediments are likely to behave.

Several field and pilot studies have been conducted on wetlands, experimental ponds and test pits containing mature fine tailings (Leonhardt 2003; MacKinnon and Boerger 1986; van den Heuvel et al. 1999; Smits et al. 2000; Zyla and Prepas 1995). These studies have found that aquatic species can survive and grow in wetlands and pit lakes containing MFT and that there were no observed affects on species that feed on aquatic organism in these environments. In addition, benthic invertebrates were found in demonstration ponds containing MFT capped with both tailings water and clean water (Leonhardt 2003). Abundance and richness were not substantially different in the process-affected water ponds from those observed in the clean water ponds. While the sediments of pit lakes have not been quantitatively modelled, the results of field studies such as the ones mentioned above indicate that pit lakes will provide aquatic habitat in the long term.

References:

- Leonhardt, C.L. 2003. *Zoobenthic Succession of Constructed Wetlands in the Fort McMurray Oil Sands Region*. Developing a Measure of Zoobenthic Recovery." Diss. University of Windsor,
- MacKinnon, M.D. and H. Boerger. 1986. *Description of Two Treatment Methods for Detoxifying Oil Sands Tailings Ponds Water*. Water Poll.Res.J.Canada.21(4):496-512.
- Smits, J.E., M.E. Wayland, M.J. Miller, K. Liber and S. Trudeau. 2000. *Reproductive, Immune, and Physiological End Points in Tree Swallows on Reclaimed Oil Sands Mine Sites*. Environmental Toxicology and Chemistry 19.12: 2951-60.

van den Heuvel, M.R., M. Power, M.D. MacKinnon and D.G. Dixon. 1999. *Effects of Oil Sands Related Aquatic Reclamation on Yellow Perch (Perca flavescens). I. Water Quality Characteristics and Yellow Perch Physiological and Population Responses*. Canadian Journal of Fisheries and Aquatic Science.56: 1,213:1,225.

Zyla, W. and E. Prepas. 1995. *The effects of nutrient additions of phytoplankton from Syncrude Canada Ltd.'s water capped lake*. Technical Report. Syncrude Canada, Edmonton, AB. May 1995.

Request:

- ii. **Describe how the storage of MFT in pit lakes corresponds to the performance requirements of ERCB Directive 074 and more generally how this unproven technology corresponds with the objective of minimizing the retention of fluid tailings in the reclamation landscape.**

Response:

- ii. Industry and regulators recognize that several technologies are being tested to reclaim oil sands tailings (e.g. end pit lakes, polymer drying, consolidated tailings, centrifuges etc.). ERCB Directive 074 requirements are based on targeting percentages of fines capture in trafficable deposits which improve probable success for reclamation. However, some fluid tailings, although significantly reduced through D074, will exist and may be left after mine closure, which is not inconsistent with D074.

Shell is testing technologies and monitoring the success of other operators in capturing tailings fines and thus reducing fluid tailings. Shell is of the opinion that the tailings technologies being tested will be successful and fluid tailings will be eliminated from pit lakes.

Request:

- iii. **Describe Shell's environmental and economic liabilities associated with the retention of mixed fluid-containing structures in a reclamation landscape.**

Response:

- iii. Shell's mine closure and reclamation plans consider the design and lifespan of fluid retention structures, and how any environmental and economic liabilities will be addressed in the closure landscape. As is the case for all oil sands mines, Shell Jackpine Mine and Muskeg River Mine are required to address the liability associated with all landforms through the Mine Financial Security Plan (as will any new approved mine areas). These bond systems assess liability up to and including the point at which fluid-containing structures are either decommissioned as fluid retention structures (eg. by decommissioning a dyke wall when the tailings content has consolidated and will not

move in the External Tailings Facilities) or designed into the landscape such that no fluid-retention structures are required (e.g. pit lakes at below original topography). At this point, the environmental and economic liabilities have been addressed and application for certification of the structure will require a thorough review and inspection to confirm this.

22. Cumulative effects of the discharges from multiple end pit lakes into regional waterbodies not adequately assessed.

Request:

- i. Discuss the current status of the testing of end pit lakes, as a provisionally approved mining feature, and prospective options to displace this as yet unproven technology.**

Response:

- i. As a member of regional stakeholder committees, Shell participates in research into issues that are of regional interest, such as pit lakes. Presently, CEMA has two groups dedicated to pit lake research: the End Pit Lake Guide Task Group and the End Pit Lake Modelling Task Group.

The End Pit Lake Guide Task Group is presently working to complete the next draft of the End Pit Lake Technical Guidance Document. It is presently following the directions provided by the peer reviewers of the first draft; namely the task group has contracted an editor, specialized experts for topic areas as well as scientific advisors and peer reviewers for each chapter. The document is on track for delivery by 2012, as per the current schedule.

The End Pit Lake Modelling Task Group is presently developing a mechanistic model that incorporates sediment diagenesis, biogenic gas production and bubble dynamics. The model will be released to pit lake planners for design and assessment of oil sands pit lakes before the end of 2011.

Pit lakes are the result of voids (pits) left at the end of mining, which fill with water. This water will contain diminishing levels of reclamation waters for a period of time. Although it might be possible to account for the volume of bitumen displaced through replacement of unconsolidated tailings and overburden, such material rehandling would be impractical. This material would eventually consolidate resulting in topographic depressions where reclamation waters would collect.

Pit lakes provide a key function in the treatment of long-term reclamation drainage water and are desirable since they function as treatment systems for long-term reclamation drainage water and, ultimately, evolve into biologically self-sustaining features of the landscape.

While Shell is confident that its pit lake designs will be successful, pit lake waters can be enhanced through a variety of means, as discussed elsewhere (Gammons et al., 2009). In addition, in the unlikely event that ongoing CONRAD and CEMA pit lake research, demonstration pit lake trials and individual operator experiences with MFT in pit lakes proves unsupportable, or indicates a threshold volume of MFT above which acceptable effects cannot be achieved, Shell will address this issue prior to filling its lakes.

References

Gammons, C. H., Harris, L.N., Castro J.M., Cott, P.A. and Hanna, B.W. 2009. Creating lakes from open pit mines: processes and considerations – with emphasis on northern environments. Can. Tech. Rep. Fish. Aquat. Sci. 2826: ix + 106 p.

Request:

- ii. Assess the cumulative impact of the discharges of multiple pit lakes in the region on water quality in regional waterbodies and on downstream ecosystems.**

Response:

- ii. Cumulative discharges from all pit lakes were included in the Athabasca River assessment. Cumulative discharges in the Base Case and Application Case were included in the EIA, Volume 4A, Section 6.5.7. Cumulative discharges from pit lakes in the Planned Development Case were included in the EIA, Volume 4B, Appendix 4-8, Section 3.2. Under conservative scenarios, the modelling predicted negligible changes to water quality in the Athabasca River.

Request:

- iii. Identify how the cumulative impact of multiple pit lakes discharges in the region would affect the ACFN's Rights and traditional use of the River.**

Response:

- iii. Shell's understanding is that all oil sands mining operators to date have made the commitment that no pit lake water will be released until it meets applicable water quality criteria. As discussed in Volume 4A, Section 6.4.5, after mine closure in 2065, the expected mean annual flow in the lower Muskeg River (Node M3) will be slightly higher than the pre-development values. The mean open-water flow and the 10-year

peak flow will be reduced and the ice-cover flow and 7Q10 low flow will be increased due to the attenuation effects of the pit lakes.

The incremental increase to the annual average and maximum flow depth will be less than 0.5%. Hence, the small change to flow rates and flow depth will have minimum effect on the ability to use the Muskeg River for access to upstream location. Accordingly, there are no anticipated cumulative impacts from multiple pit lake discharges on the exercise of ACFN's traditional activities.

23. Cumulative impacts on regional waterbodies from process-affected seepage not assessed.

- i. Identify the impact of the cumulative effects of regional tailings seepage on groundwater and surface water quality and on downstream ecosystems (including the sediments of the Athabasca River and the Peace-Athabasca Delta), against a pre-industrial baseline.**

Response:

The Athabasca River assessment included cumulative seepages from all projects. Cumulative seepages in the Base Case and Application Case were included in the modelling conducted for EIA, Volume 4A, Section 6.5.7. Cumulative seepages from pit lakes in the Planned Development Case were included in the EIA, Volume 4B, Appendix 4-8, Section 3.2. Under conservative scenarios, the modelling predicted negligible changes to water quality in the Athabasca River.

See Section 1.0 of the JME Technical Review document for an explanation of why a pre-industrial assessment case was not used.

Requests:

- ii. Discuss the apparent contradiction between modeled forecast for the concentrations of toxins in the Athabasca River and current data presented in Timoney & Lee (2009) that suggests that the impacts are already significant.**

Response:

Timoney and Lee (2009) present a series of analyses to support their position that the oil sands industry (1) presents an ecosystem or human health concern, (2) has

increased concentrations in the Athabasca River downstream of development, compared to upstream, (3) has increased levels of contaminants over time and (4) has documented incidents of industrial pollution or degradation. Timoney and Lee (2009) state that “RAMP was found unable to measure and assess development-related change locally or in a cumulative way”. They subsequently use RAMP data to attempt to demonstrate development-related change in a local and cumulative way.

There are several issues with the treatment of data and drawing of conclusions by Timoney and Lee (2009), as pointed out in the recent Royal Society of Canada report on the oil sands (Gosselin et al. 2010). A few of the most notable issues are:

- the lack of reference condition in all of the comparisons;
- the inference of causal relationships without justification by data analysis; and
- the inference of health concerns without completion of a health risk assessment.

Because of such issues, the conclusion by Timoney and Lee (2009) that impacts are already significant is not supported.

References:

Gosselin P., Hurdey, S.E., Naeth M.A., Plourde A., Therrien R., Van Der Kraak G., Xu Z. 2010. The Royal Society of Canada Expert Panel: Environmental and Health Impacts of Canada’s Oil Sands Industry. Available at: The Royal Society of Canada Expert Panel: Environmental and Health Impacts of Canada’s Oil Sands Industry

Timoney, K.P. and P. Lee 2009. Does the Alberta Tar Sands Industry Pollute? The Scientific Evidence. The Open Conservation Biology Journal. 3:65-81.

Request:

- iii. Discuss how the cumulative impacts of regional tailings seepage will affect the ACFN’s Rights and use of traditional resources.**

Response:

- iii. As stated in Volume 3 of Shell’s JME EIA, Shell has assumed that all regional ETDAs will employ the mitigation measures as outlined in their respective EIAs, as those mitigation measures are effectively approval conditions. On this assumption, Shell has

engaged in a cumulative effects assessment for water quality in regional streams, lakes and other waterbodies within the JME LSA and RSA, and concluded that potential transport of Polycyclic Aromatic Hydrocarbons (PAHs) and metals are predicted to result in negligible changes in receiving waterbodies and watercourses. Given these predictions, and given the predicted negligible impacts to receiving waterbodies due to ETDA seepage due to mitigation measures as contained in respective EIAs, it is not expected that cumulative negligible impacts will affect the ACFN's rights and uses of traditional resources

24. Proposed bridge and pipeline pose risk to Athabasca River water quality.

Requests:

- i. Assess the potential effects a worst - case pipeline spill or rupture would have on the Athabasca River, on its downstream ecosystem, and on the ACFN.**

Response:

Shell incorporates a hazards and effects management process (HEMP) as a key part of its health, safety, security, and environment (HSSE) management systems. HEMP is used for identification and risk assessment of HSSE hazards, the evaluation and implementation of control and recovery measures, and to document that major HSSE risks have been reduced to as low as practicable. Its aim is to ensure hazards are identified, the risks assessed and proper barriers put in place to prevent or recover from an HSSE event, such as the accidents and malfunction noted below. The HEMP process will further inform detailed designs for the bridge and intake. The potential residual effects of the Project, after mitigation, are assessed in the Application Case presented in the EIA (Volume 4A, Sections 6.4.7 and 6.7.7). Project effects, which inform the Application Case, include those related to the proposed Athabasca River bridge and the Pierre River Mine river water intake, as well as effects of water withdrawals.

In the December 2009, Jackpine Mine Expansion Project Supplemental Information, SIR 313, a discussion of aquatic effects related to accidents and malfunctions, which includes a discussion on effects from spills, was provided. Relevant excerpts of that response are paraphrased below.

Spills or Leaks

Spills or leaks could adversely affect the water quality of watercourses in or adjacent to the project area if the spilled contents are deleterious to aquatic life and the contents reach a watercourse. Whether a spill or leak will reach a watercourse will depend on the volume spilled, the direction the spill disperses and the proximity of the accidental spill or leak site to a watercourse. Spills or leaks could occur along any pipeline or road that is used to transport potential deleterious substances including dilbit, fuels and tailings slurry. The likelihood of spills or leaks reaching the Athabasca River from the proposed bridge is low based on the following proposed controls:

- liquid substances used by the projects and wastes generated by the projects have been identified, and barriers, such as secondary containment and leak protection have been proposed, where appropriate.
- pipelines will be designed using best management practices specific to the substance carried and pipeline capacity. These practices could include geotechnical assessments of pipeline crossings, isolation valving and where appropriate, leak detection and shut down systems.
- project activities will follow HSSE protocols (e.g. speed limits, work practices, fire prevention) designed to reduce accidental spills and reduce effects if a spill occurs

Requests:

- ii. Provide a conceptual plan for protecting fish habitat from disturbance and destruction during the construction and use of the bridge, and present a concept for fish habitat compensation in the case where fish habitat would be destroyed.**

Response:

The Habitat Compensation plan for the project does not specifically address the proposed bridge crossing over the Athabasca River as detailed bridge designs and specifications are not available at this time. However, bridge construction is anticipated to result in a small-scale permanent loss of habitat within the Athabasca River due to in-stream piers or abutments. In addition, there will be associated disruption to fish habitat due to mitigation efforts designed to protect fish habitat such as isolation of instream construction areas.

A separate application for a federal Fisheries Act Section 35(2) Authorization will be submitted for the bridge construction once detailed engineering designs are produced. The Authorization will specify mitigation, habitat compensation, and monitoring that Shell will be required to complete. Best management practices and mitigation measures will be employed to ensure that any potential habitat or fisheries impacts during construction are minimized or eliminated. Any remaining residual impacts to fish habitat (e.g., habitat loss due to instream piers) will be offset by compensation measures as required by regulators, and may be incorporated into the overall project compensation habitat. A monitoring plan during construction and for compensation habitat will be developed in consultation with regulators.

Requests:

- iii. Assess the potential impacts that increased access due to the bridge and road would have on wildlife abundance and, ultimately, on ACFN Rights.**

Response:

The bridge and the access road to the Pierre River Mine will not be open to the public during project operations and Shell will decommission the bridge during the closure period. Therefore, there will not be an increase in access as a result of the Project. As stated in Section 8.4.6.2 of Volume 5 of the EIA (page 8-92):

Changes in access are not expected to be significant in the context of resource use because although new access routes may be created, access control measures will not permit public use.

1.4 Aquatic Health and Fish / Fish Habitat

25. Benchmark exceedances of several aquatic health constituents dismissed.

Request:

- i. Provide appropriate and meaningful pre-industrial benchmarks for aquatic health constituents, such that compliance and non-compliance can be better assessed.**

Response:

- i. Overall, the benchmarks used in the assessment of potential effects of the Project on aquatic health although conservative can be considered meaningful as a stringent method was applied to their development and application (Appendix 4-2, Section 2 of the EIA).

Health benchmarks are based on reviews of toxicity data. Toxicity studies on potential contaminants which pertain to species living in the northern Oil Sands Region are used to create a database of potential effects to aquatic life. Two approaches are then used to develop an aquatic health benchmark.

If the toxicity data set for a substance was small (i.e., less than 5 species from the region) a safety factor approach was used. Once the data set is compiled and assessed for reliability then the critical studies are selected for chronic effects. The critical studies are typically the lowest reliable chronic toxicity values. The final benchmark(s) are then derived by application of a safety factor to produce benchmarks that are below the lowest toxicity value and are therefore deemed to provide a high level of protection for all species in the ecosystem.

If the toxicity data set for a substance is large (i.e., more than 5 species from the region) a species sensitivity distribution (SSD) was created. The data for chronic toxicity are ranked from lowest (most sensitive) to highest (least sensitive) and a distribution is fit to the ranked data set. The SSD allows for selection of a value that is protective of some specified percentage of species. Typically, the 5% value (referred to as the HC₅ - hazardous concentration potentially harmful to 5% of species) is selected as the benchmark, representing the concentration at which no more than 5% of species will be affected (i.e., 95% of species are protected).

The process of identifying benchmarks is the same regardless of the level of disturbance in a system (i.e., the benchmarks identified in the EIA would apply to the pre-development or Application Case Scenarios).

Request:

- ii. **Discuss the current utility of these benchmarks, how they may be improved in the future.**

Response:

- ii. The benchmarks used in the EIA were derived specifically for the 2007 submission of the JME and PRM Project. A review of more recent toxicity information was conducted for organic compounds and metals. This review for organic compounds did not change the conclusions of the EIA and validated the benchmarks used in the EIA. New studies regarding metals toxicity were not found during the review.

Please see the response to 23ii for further information on benchmarks for aquatic health constituents.

Request:

- iii. **Describe Shell's commitment to improve the science in this critical input to the ERCB's public interest determination.**

Response:

- iii. Shell is committed to following the process described in the responses to 23i and 23ii, which reflects sound science.

26. Assessment on aquatic health for benchmark exceedances lacking.

Requests:

i. Discuss the potential effects of the predicted benchmark exceedances on aquatic health.

- i. The discussion on the potential effects of the predicted benchmark exceedances was conducted as part of the EIA. The discussion begins in Volume 4A, Section 6.6.4 and the exceedances are highlighted in Tables 6.6-4 to 6.6-7. Four lines of evidence were used in the classification of residual effects – change in sediment chemistry, toxicity testing of tailings water, comparison of predicted fish tissues to tissue residue benchmarks and, water chemistry compared to aquatic benchmarks,.

As discussed in Shell (2007), changes to sediment chemistry are expected to be negligible in LSA watercourses/waterbodies. Whole effluent and chronic toxicity levels in the Muskeg River, Jackpine Creek and Kearl Lake are predicted to be non-toxic throughout the life of the project and into the far future. Parameter concentrations in fish tissues are also predicted to remain below toxicological benchmarks.

The exceedance of individual benchmarks was examined in Tables 6.6-12 to 6.6-15. Chromium and strontium were predicted to have low magnitude of effect in Muskeg River and Jackpine Creek. In Kearl Lake, cadmium and strontium were predicted to have low magnitude effect.

References:

Shell (Shell Canada Limited). 2007. Application for Approval of the Jackpine Mine Expansion & Pierre River Mine Project. Prepared by Golder Associates Ltd. for Shell Canada Ltd. Submitted to Alberta Energy and Utilities Board and to Alberta Environment. December 2007, provided on CD/DVD.

Request:

- ii. Describe Shell's monitoring plan for predicted benchmark exceedances on aquatic health, both on lease and off lease.**

Response:

- ii. The preliminary draft of the monitoring plan is described in Appendix 4-9 and the detailed plan will be finished as part of the permitting process. Shell will also continue to participate in RAMP and discussions for its improvement in monitoring for regional effects.

Parameters which will be examined are displayed in Appendix 4-9, Table 7. Proposed monitoring locations include:

- Muskeg River;

- Wapasu Creek;
- Pierre River;
- Asphalt Creek;
- First Creek;
- Big Creek; and
- Redclay Compensation Lake

Requests:

- iii. Discuss the effect of decreasing pH levels on the mobilization of metals and other contaminants. Include a description of the regional trends in pH and metal mobilization.**

Response:

The pH is not predicted to change in regional watercourses (see EIA: Volume 3, Section 5.5.5). Therefore, there is no valid linkage between this project and pH-driven metal mobilization.

Request:

- iv. Discuss the methods available and their costs to reverse the impacts predicted.**

Response:

- iv. The mitigation outlined in EIA Volume 4, Section 6.1.4.3 will be implemented to reduce the effects of the Project on water quality and aquatic health. These mitigation measures were considered in the Aquatic Health Assessment in determining residual impact calculations. The Project is predicted to result in negligible to low environmental consequence ratings for Aquatic Health, so no additional mitigation is considered necessary.

Request:

- v. Discuss Shell's commitment to change its technical methods and associated emissions if actual contaminant levels exceed predicted values.**

Response:

- v. The intent of the EIA for the proposed projects is to provide a conservative assessment of potential impacts of the project. Shell recognizes that predictive

approaches require validation and has accordingly committed to monitoring, and adaptive management should contaminant levels exceed regulatory requirements.

27. Fish habitat impacts due to thermal changes unclear.

Requests:

- i. Reassess the impact rating for temperature changes to Eymundson Creek that better reflect the predicted data; describe the extent of the changes in temperature along the length of the river; and discuss the effects of these temperature changes on other water quality constituents, particularly dissolved oxygen.**

Response:

For the purpose of assessing changes to fish habitat, lower Eymundson Creek was considered to be lost in its entirety as a result of project developments (see EIA, Volume 4, Section 6.7.7.2, page 6-644 and Table 6.7-19). As a result, any change in habitat within the diversion channel resulting from a change in water quality has been accounted for as part of the fish habitat area lost, as described in the conceptual compensation plan (see EIA, Volume 4, Appendix 4-6, Table 7), and will be compensated in accordance with an approved No Net Loss Plan, which is currently under development.

Flow from Eymundson Creek will be passed through a diversion channel. The assessment presented in the EIA represents conditions within the diversion channel that will convey Eymundson Creek flows. In the 2049 snapshot (when pit lake discharges begin) delayed warming in the summer and delayed cooling in the fall and winter is predicted in the diversion channel (Section 6.5.6.3); however, the impact on other water quality parameters and biological receptors is expected to be negligible.

Polishing pond outflows are not expected to appreciably reduce background dissolved oxygen (DO) levels in the diversion channel. This prediction is consistent with potential effects pathway evaluations for DO of previous oil sand EIA's that predicted no significant changes in DO (CNRL 2002; Shell 2002a,b; True North 2001) from similar polishing ponds and monitoring results for Shell's active polishing ponds at JPM.

References:

CNRL (Canadian Natural Resources Limited). 2002. Horizon Oil sands Project – Application for Approval. Volume 1 Prepared by Canadian Natural Resources Limited. Volumes 2-8, Prepared by Golder Associates Ltd. For Canadian Natural resources Limited. Submitted to Alberta Energy and Utilities Board and Alberta Environment. Calgary, AB. Submitted June 2002.

Shell (Shell Canada Limited). 2002a. Jackpine Mine – Phase 1 Application, Environmental Impact Assessment and Socio-Economic Assessment. Volumes 1-7. Prepared by Golder Associates Ltd., Komex International Inc., Cantox Environmental Inc. and Nichols Applied Management. Calgary, AB. Submitted May 2002.

Shell. 2002b. Jackpine Mine – Phase 1 Supplemental Information. Golder Associates Ltd., Komex International Inc., Cantox Environmental Inc. and Nichols Applied Management (ed.). Calgary, AB. Submitted December 2002.

True North (True North Energy). 2001. Application for Approval of the Fort Hills Oil Sands Project. Submitted to Alberta Energy and Utilities Board and Alberta Environmental Protection. Prepared by AXYS Environmental Consulting Ltd. And Golder Associates Ltd. Calgary, AB.

Requests:

- ii. **Clarify whether Eymundson Creek would have fish or other aquatic life in it in 2049 that would be exposed to these large thermal changes. If so, identify the expected species and the impacts associated with temperature fluctuations.**

Response:

Expected thermal changes are not large and are not expected to have any negative effect on aquatic life. Currently, Eymundson Creek provides suitable habitat for 11 species of fish; primarily forage fish with some seasonal habitat use potential in the lower reach for large-bodied fish species from the Athabasca River. The fish community in Eymundson Creek was dominated by forage fish throughout, with the occurrence of sport fish (Arctic grayling and burbot) and non-sport fish (longnose and white sucker) only found in the lower reaches directly adjacent to the Athabasca River. These species are considered cold or cool-water species and can tolerate temperature variations of the magnitude expected.

The delayed warming in the summer and delayed cooling in the fall and winter predicted in diversion channel post 2049 are not expected to reduce the availability or suitability of fish habitat for these species. As such, species diversity is not expected to change in upper Eymundson Creek or the Athabasca River as a result

of the Project. Lower Eymundson Creek supports benthic communities with low diversity (Golder 2007). The small thermal changes predicted are not expected to reduce the diversity of benthic invertebrate communities.

References:

Golder (Golder Associates Ltd.). 2007. Aquatics Environmental Setting Report for the Jackpine Mine Expansion and Pierre River Mine Project. Prepared for Shell Canada Ltd. Calgary, AB. Submitted December 2007.

Requests:

- iii. Assess the current and potential cumulative impacts of shifts in water temperature on fish or other aquatic organisms located in waterbodies, tributaries and the Athabasca River from current and planned oil sands projects against a pre - industrial baseline.**

Response:

The Pierre River Mine (PRM) is located within the Pierre River, Asphalt and Eymundson Creek, Big Creek and Redclay Creek watersheds, which have not been affected by existing oilsands developments. There is also no evidence to suggest that current developments in the lower Athabasca basin have affected the water temperature of watercourses within these watersheds. As such observed water temperature (up to 2007) is reflective of pre-development conditions in the PRM development area (EIA, Vol4A, Section 6.5.3.5). The PRM will not affect the thermal regime within the Pierre River, Asphalt Creek, Big Creek or Redclay Creek watersheds (EIA, Vol4A, Section 6.5.6.3). The only predicted thermal regime change is for Eymundson Creek, which is discussed above in response to questions 27i and 27ii. No measurable thermal effects are predicted in the Athabasca River due to the project as dewatering release waters and pit lake outflows are small relative to the Athabasca River flow. As discussed in the Surface Water Quality assessment (EIA, Vol4A, Section 6.5.7.1), due to the large volume of flow in the Athabasca River, cumulative discharges from existing and approved developments into the Athabasca River or its tributaries are not predicted to have significant effects on water temperatures in the Athabasca River. Consequently, there would be no significant effects on aquatic organisms.

Given that temperature effects on receiving waters will be localized and not significant, and taking into account mitigation measures and habitat compensation, the impacts of the predicted changes in thermal regime on fish habitat or abundance in the Athabasca River resulting from PRM are considered negligible.

28. Effects on fish habitat are not extrapolated to fish abundance.

Request:

- i. Discuss the potential impacts of changes to fish habitat, on fish abundance, and local and regional fish populations.**

Response:

- i. The Shell No Net Loss Plan, which is currently under development, will be designed to meet the DFO regulatory requirements for fish habitat compensation and no net loss of fish habitat. The result will be no significant negative impacts to the fishery. There will be a change in fish species distributions as the compensation habitat supports more fish species and a larger biomass of sport fish than the habitat it replaces.

Request:

- ii. Assess the change in impacts if Shell fully adopts the intention of ERCB Directive 074 and commits to no residual fluid tailings (and thus no associated liabilities) in the reclamation landscape.**

Response:

- ii. While ERCB Directive 074 does not require elimination of residual fine tailings, Shell's intention is to eliminate storage of its JME mature fine tailings (MFT) in its proposed pit lakes. Elimination of MFT from its pit lakes will not reduce the fisheries impact as the project continues to have the same disturbance footprint.
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29. Productive capacity of fish habitat not determined.

Request:

- i. Provide details on the productive capacity of the habitat losses and compensation habitat.**

Response:

- i. The productive capacity of fish habitat is assessed by modelling the habitat units present in the impacted and the compensation habitat using models and an

approach agreed to by all the stakeholders (including ACFN), the regulators and industry. The detailed preliminary results of the calculations have been provided to ACFN and considerably more detail will be provided in the upcoming No Net Loss Plan.

References:

U.S. FWS (United States Fish and Wildlife Service). 1980. *Habitat Evaluation Procedures (HEP)*. USFWS, Division of Ecological Services. ESM 102. U.S.D.I.

Request:

- ii. Provide all information necessary to prove that the compensation habitat would provide at least a 2:1 compensation ratio.**

Response:

- ii. Compensation will be provided to meet regulatory requirements, but those requirements are not necessarily required to be 2:1. Preliminary results of the draft No Net Loss Plan modelling have been provided to ACFN. Detailed information will be provided in the upcoming draft No Net Loss Plan.

Request:

- iii. Provide species-specific habitat losses, and discuss these impacts on fish species currently experiencing stress and population declines in the region.**

Response:

- iii. All species affected by the project will be addressed in the upcoming draft No Net Loss Plan.

Request:

- iv. Given the uncertainties with the ability of the Compensation Lake to adequately compensate for lost aquatic resources or traditional use, discuss how the NNL Compensation Lake will impact the ACFN's Treaty and Aboriginal rights.**

Response:

- iv. There is very little uncertainty regarding the ability of engineered reservoirs to support aquatic life and ecosystems, as there are numerous such operational facilities throughout Alberta and Canada. The Shell No Net Loss Plan, which is currently under development, will be designed to meet the DFO regulatory requirements for fish habitat compensation and no net loss of fish habitat. The result will be no significant negative impacts to the fishery. There will be a change in fish species distributions as the compensation habitat supports more fish species and a larger biomass of sport fish than

the habitat it replaces. As a result, there will be no significant adverse effects to ACFNs traditional fishing activities.

Request:

- v. **Provide the ACFN with the draft No Net Loss Plan, when available, for review and comment.**

Response:

- v. Shell will provide the draft plan to ACFN for review when it is available.
-

30. Compensation for riverine habitat lacking.

Request:

- i. **Discuss the lack of riverine habitat and the regional implications from this plan and other fisheries habitat compensation plans - which focus almost entirely on lacustrine habitat compensation.**

Response:

- i. Riverine compensation will form part of the compensation habitat as described in Section 5.3.2 of the Conceptual Compensation Plan (Appendix 4-6 of the EIA), which includes an outlet and inlet channel to the compensation lake that will provide fish habitat and connect the lake with the Athabasca River. In addition, all permanent closure channels will be geomorphically designed to provide fish habitat as well as provide access for fish from the Athabasca River to upper watershed reaches and tributaries. The closure channels will provide approximately 28 km of riverine fish habitat as compensation.

Although riverine habitat is part of the compensation plan, it is not possible to provide all the required compensation for riverine habitat as riverine habitat. A self-sustaining lake can be built with minimal impact to existing fish habitat. But the construction of a stream of the size required to achieve no net loss of fish habitat will divert watershed area from existing streams and cannot be constructed without large impacts to existing streams. Therefore, no gains are possible with a strict riverine for riverine compensation strategy.

On closure, watersheds will be connected and a considerable amount of riverine habitat typical of the habitat being disturbed will be developed that will also support fish. However, that habitat is currently not accepted as compensation by DFO.

All of the fish that use the streams impacted by the project also use lake habitat. However, the lake habitat will support higher average diversity of fish species and a higher biomass of sportfish than the habitat impacted by the project. Regionally, compensation lakes will improve fishing opportunities relative to the pre-development habitat.

Request:

- ii. **Discuss Shell's commitment to address this critical aspect of the impacts on the ACFN's Treaty and Aboriginal rights, and to provide the ERCB with information essential to the Public Interest determination.**

Response:

- ii. Shell is committed to providing compensation for all fish habitat in accordance with DFO's regulatory requirements, which will result in no net impact to the fishery resource. The taking up of lands for the purposes of the compensation lake is being undertaken, in part, to mitigate impacts to the exercise of traditional fishing rights.
-

31. Compensation timing details unknown.

Request:

Provide details regarding the timing of the construction of compensation habitat, and when they will be capable of supporting fish and other aquatic organisms as part of a sustainable and diverse ecosystem. Discuss the local and regional implications of this and other compensation plans that will not provide compensation habitat at the same time as habitat losses.

Response:

The timing of construction of compensation habitats will be specified as a condition of the *Fisheries Act* Authorization for the Project after approval by DFO of the final NNLP. In recent DFO approvals, the timing for the compensation is closely related to the timing of the HADD it is compensating for, minimizing time lags. The timing of fish habitat compensation is one of the factors considered when determining the appropriate compensation ratio for a project. The greater the time lag, the greater the compensation ratio. Shell would have the option of building compensation before the impacts which would reduce the compensation requirements.

The lake will provide fish habitat as soon as it is filled and it is expected there will be a burst of productivity and biomass typical of reservoirs that will last for a decade or more.

Then it is expected that productivity will drop back to a long-term sustainable level typical of regional lakes of the same habitat quality once the nutrients associated with flooding terrestrial areas are no longer available.

Given that the existing habitat being impacted provides almost no food fishery value while the compensation habitat will provide significant fisheries values, there will be a regional gain in fishing opportunities. Similarly, compensation plans developed by other operators typically also replace impacted habitat that provided no or marginal fishery opportunities with compensation habitat that provides improved fishery opportunities.

32. Impacts of mercury releases from NNL compensation reservoir not considered.

Request:

- i. Discuss the concentrations of mercury and methylmercury likely to be present within the aquatic ecosystem (including sediment, water column, aquatic plants, plankton, benthic invertebrates and fish), at a variety of time-scales (e.g., construction, 1 year post-construction, 5 years post-construction, far future, etc.).**

Response:

- i. To mitigate the production and uptake of methylmercury in Redclay Compensation Lake, Shell will implement intensive fishing and other mitigations described in part ii of this question. The intensive fishing strategy has been implemented in Sweden (Gothberg 1983), Finland (Verta 1990), and in Quebec (Surette et al. 2003, 2006; Masson and Tremblay 2003) and has been shown to successfully reduce mercury concentrations in fish.

For the purposes of this assessment, mercury concentrations were predicted in various media to obtain conservative estimates of worst-case conditions. Concentrations were predicted based on surrogate systems, considering intensive fishing wherever possible.

Water concentrations were estimated by taking modelled predictions for Redclay Compensation Lake, not considering methylmercury production, then applying a multiplication factor of 10-20, as has been observed in similar systems (Bodaly et al. 1997). There are no pre-flooding estimates available for benthic invertebrates and plankton, so these were assumed to be similar to values from literature. Estimated values for these organisms were obtained from the range of values from similar systems that were intensively fished (Surette et al. 2006). The range of values listed for zooplankton were obtained from Bodaly et al. (1997), which was a metaanalysis of reported concentrations of total mercury in zooplankton collected from unimpounded

lakes and impounded reservoirs at different times after impoundment. For walleye and whitefish, the range of mercury values are based on other systems that are intensively fished (Surette et al. 2006).

For more information on mercury concentrations in water and other organisms, please see Table 29-1. The table presents starting concentrations and peak concentrations. One-year concentrations would be similar to pre-construction values, at least for fish. It was assumed that the values of interest for the 5-year concentrations were the peak values. The 5-year concentrations would be similar to peak concentrations, although the timing of the peak is variable and would not necessarily occur at 5 years. Even without mitigation, in 20-30 years concentrations fall to background levels (Bodaly et al. 2007) as would far future concentrations.

The Athabasca River Model was used to estimate the increased mercury concentrations in the Athabasca River as a result of discharges from Redclay Compensation Lake. As a conservative case, mercury concentrations in the outflow from Redclay Compensation Lake were assumed to be at the maximum of the identified range of potential concentrations. The model was run with all other inputs to the Athabasca River Model the same as those presented in the EIA, Volume 4A, Appendix 4-2, Section 2.1.3 for the closure snapshot under the planned development case. Mercury concentrations in the Athabasca River downstream of Big Creek were predicted to increase by less than 1 ng/L under this worst-case scenario.

Table 32-1 Mercury Concentrations in Water and Other Organisms

Medium		Guidelines	Units	Background (Natural Waters Pre-Impoundment)	Conservative Case Estimated Peak Value (Post Impoundment)	Estimation Method
Water	THg	0.005 µg/L	mg/L	0.00000093 (EIA)	0.0000093 to 0.0000186	10 to 20 times increase over background values (Bodaly et al. 1997)
Benthic Inverts	THg	-	ng/g dw	-	245 to 311	Range of values from other systems that are intensively fished from Surette et al. 2006
	MeHg	-	ng/g dw	-	70 to 165	
Plankton	THg	-	ng/g	-	76 to 175	
	MeHg	-	ng/g	-	20 to 120	
Zooplankton	THg	-	µg/g dry wt	0.083 to 0.458	0.085 to 2.125	Literature values from other systems from Figures 4 and 5 (Bodaly et al. 1997)
	MeHg	-	ng/g dry wt	33.3 to 208	16.6 to 375	
Walleye	THg	0.2 – 0.5 µg/g	mg/kg ww	-	0.378 to 0.460	Range of values from other systems that are intensively fished (Surette et al. 2006)
				0.061 to 0.72 (RAMP, regional in range)	0.7-2.6	For walleye and northern pike without mitigation from Bodaly et al. 2007
Whitefish	THg		mg/kg ww	-	0.064 to 0.090	Range of values from other systems that are intensively fished (Surette et al. 2006)
				0.0196 to 0.18 (RAMP)	0.2-0.4	Without mitigation from Bodaly et al. 2007

References:

Bodaly, R.A., V.L. St Louis, M.J. Paterson, R.J.P. Fudge, B.D. Hall, D.M. Rosenberg and J.W.M. Rudd. 1997. *Bioaccumulation of mercury in the aquatic food chain in newly flooded areas, Mercury and its Effects on Environment and Biology* 34.

Bodaly, R.A.D. and Jansen, WA and Majewski, AR and Fudge, R.J.P. and Strange, NE and Derksen, AJ and Green, DJ. 2007. Postimpoundment time course of increased mercury concentrations in fish in hydroelectric reservoirs of northern Manitoba, Canada. *Archives of environmental contamination and toxicology* 53(3): 379-389.

Gothberg, A. 1983. *Intensive fishing-a way to reduce the mercury level in fish*. *Ambio*. 12:259-61.

Masson, S. and A. Tremblay. 2003. *Effects of intensive fishing on the structure of zooplankton communities and mercury levels*. *The Science of the Total Environment* 304: 377—39.

RAMP (Regional Aquatics Monitoring Program). 2010. *Regional Aquatics Monitoring Program: 2009 Technical Report - Final*. Prepared for the RAMP Steering Committee by Hatfield Consultants Ltd., Kilgour and Associates Ltd. and Western Resource Solutions.

Schetagne, R., J. Therrien and R. Lalumière. 2003. *Environmental Monitoring at the La Grande Complex. Evolution of Fish Mercury Levels*. Summary Report 1978–2000. Direction Barrages et Environnement, Hydro-Québec Production and Groupe conseil GENIVAR inc. 185 p. and appendix.

Surette, C. M. Lucotte, J. Doire and A. Tremblay. 2003. *Mercury bioaccumulation in fish: effects of intensive fishing in three natural lakes of Northern Quebec, Canada*. *J Phys IV*; 107:1443–1443.

Surette, C., M. Lucotte and A. Tremblay. 2006. *Influence of intensive fishing on the partitioning of mercury and methyl-mercury in three lakes of Northern Quebec*. *Sci. Tot. Environ.*, 368(1):248-61.

Verta, M. 1990. *Changes in fish mercury concentrations in an extensively fished lake*. *Can J Fish Aquat Sci*; 47:1888–97.

Request:

- ii. **Discuss mitigations planned to minimize mercury mobilization (and conversion to methylmercury) and removal of mercury from the system.**

Response:

- ii. To minimize methylmercury generation, bioaccumulation through the food chain and associated environmental and health risks, there are several mitigation options (Mailman et al. 2006) that Shell will implement:
 - Monitor methyl mercury in fish flesh to determine if there is a problem. Mercury monitoring is included in Shell’s Compensation Habitat Monitoring Plan used for all Shell compensation habitat (Hatfield 2009).
 - Remove trees and large shrubs that will be submerged by the reservoir to remove some of the carbon, provide a safe boating environment, prevent logjams on the outlet, and allow effective intensive fishing as required.

- Stakeholders will be kept informed of the annual results of the mercury sampling and which species and sizes of fish meet and do not meet the guidelines for human consumption.
- If mercury exceeds Health Canada guidelines and background levels for any species, Shell would take the following actions until the lake fish methyl mercury concentrations return to background levels (i.e. RAMP results for the Athabasca River) or meet the Health Canada Guidelines:
 - Ask Alberta SRD to close the reservoir to recreational and domestic fishing if it isn't already closed.
 - Post warning signs around the lake and in the Alberta Fishing Guide for the relevant species.
 - Notify local stakeholders of the status of the fish in the lake.
 - Conduct intensive fishing to remove the relevant fish sizes for species that exceed the guidelines. This would entail gill-netting, set-lines and perhaps other methods targeted at specific sizes and species of fish of concern. Typically, large fish predators like walleye and northern pike would be the species most prone to high tissue concentrations. Gill netting in particular is a proven and very effective capture method that, with appropriate effort, essentially can remove the entire population of target fish within a target size range in a lake the size of the compensation lake. The capture record can be used to determine how many target fish remain in the lake and an appropriate stopping rule for the fishing program can be implemented. The culled fish would be disposed of in an appropriate waste facility.
 - If the compensation lake became a population sink for Athabasca River fish, a temporary drop structure could be installed on the outlet to prevent Athabasca fish from entering the lake during the years when intensive fishing was required.

The last two mitigation methods would be decided in consultation with regulators and stakeholders. There are various options of these two mitigations that could be implemented.

With these mitigations, mercury in fish tissue is determined to be a negligible residual human health risk. Shell is not planning to strip or cap the reservoir bottom.

References:

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- Hall, B.D., V.L. St. Louis, K.R. Rolfhus, R.A. Bodaly, K.G. Beaty and M. Paterson. 2005. *The impact of reservoir creation on the biogeochemical cycling of methyl and total mercury in boreal upland forests*. *Ecosystems*; 8(3):248 – 66.
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- Verta, M. 1990. *Changes in fish mercury concentrations in an extensively fished lake.* Can J Fish Aquat Sci; 47:1888–97.

Request:

- iii. Discuss monitoring plans to document and track over time the presence of mercury and methylmercury within the aquatic ecosystem of the planned Compensation Lake.**

Response:

- ii. See response to question 32ii.

Request:

iv. Discuss the causal links for the mobilization of mercury and other metals with changes in pH. Include a description of the regional trends in pH and metal mobilization.

Response:

In newly flooded reservoirs, pH levels may decrease due to increased dissolved organic carbon (Mailman et al. 2006). At lower pH levels, transport of mercury from the water to the atmosphere decreases (Lodenius et al. 2003; Watras et al. 1998). This may potentially increase the availability of methylmercury for uptake due to an increase in the amount of methylmercury dissolved in the water (Mailman et al. 2006).

Fish mercury concentrations tend to increase with decreasing pH (Hakanson et al. 1988; McMurtry et al. 1989; Cope et al. 1990; Grieb et al. 1990; Suns and Hitchin 1990; Wiener et al. 1990; Winfrey and Rudd, 1990; Simonin et al. 1994), and flooding of peatlands and soils rich in organic acids may promote more acidic conditions in the compensation lake. Wiener et al. (1990) showed that methylmercury concentrations in fish were negatively correlated with acidity in Little Rock Lake. In a set of Swedish lakes, Andersson et al. (1995) reported that fish mercury concentrations were highest in lakes with pH levels of 5.0. Lakes were acidified to pH values of 4.9 to 5.5, and then treated with lime to elevate pH values to 6.5 to 7.0. During this process, fish mercury concentrations decreased by up to two times (Andersson et al. 1995). In the Adirondack lakes, in New York, the concentrations of total mercury and total methylmercury were increased with decreasing pH (Figure 1; Driscoll et al. 1995). Silva-Forsberg et al. (1999) reported increased fish mercury levels at lower pH and at increased levels of dissolved organic carbon in the Rio Negro basin, Amazon. Boucher and Schetagne (1983) compared mercury in fish for pre-impoundment with post-impoundment conditions in La Grande reservoirs (in Quebec). The authors considered that a major controlling factor for methylation was a decrease in pH of surface waters from about 6.5 to 6.0, to slightly lower (5.4-5.9) pH. Scheider et al. (1979) compared mercury concentrations of walleye in 52 southern Ontario lakes and found significantly higher mercury values in low alkalinity lakes. Suns et al. (1987) found an inverse correlation between lake water pH and whole body concentrations of mercury in yearling yellow perch in 15 lakes in the Muskoka-Haliburton area of Ontario.

Methylation of mercury is reported to increase at lower pH (Bloom et al. 1991; Miskimmin et al. 1992). The reason could be that the amount of mercury bound to dissolved organic carbon decreases with acidity, which results in the release of methylmercury from sediments (Hintelmann et al. 1995). This stimulates mercury methylation because mercury can bind directly to microbial cells (Winfrey and

Rudd, 1990). Ramlal et al. (1985) found that methylation rates decreased in sediment samples as the pH was lowered, and Baker et al. (1983) found that formation of methylmercury in sediment samples only occurred at a pH range of 5.5 to 6. Xun et al. (1987) predicted that the net rate of methylmercury production in the water column and at the sediment-water surface will increase as a result of lake acidification. In their study, the changes in pH affected methylation to a greater degree than demethylation; they observed a consistent increase in the net rate of mercury methylation at lower pH. They reported that the net methylmercury production in lake water was about seven times faster at low pH (~ 4.5) than at high pH (~ 8.5) (Xun et al. 1987). Miskimmin et al. (1992) reported that net methylation rate increased with a decrease in pH from 7.0 to 5.0 at low and high concentrations of dissolved organic carbon. Similarly in Finland, Rask and Verta (1995) observed that mean mercury concentrations in perch decreased by about 50% in a lake basin amended with lime relative to the control basin (Rask and Verta, 1995). On the contrary, one study (French et al. 1999) reported that methylmercury concentrations in the lake sediment of 34 headwater lakes in Newfoundland were not related to acidity.

Fortunately, addition of lime is a safe, relatively simple and effective mitigation that can be used to raise pH and therefore lower methylmercury concentrations in newly flooded reservoirs if pH decreases due to dissolved organic carbon or other factors (Mailman et al. 2006).

As described in EIA, Section 5.5.5, the project is predicted to have a negligible effect on pH change in regional waterbodies. Given this conclusion and the relative ease of mitigating any change in pH of Redclay Compensation Lake, additional assessment of changes in pH and related effects is not necessary. Therefore, a description of the regional trends in pH and metal mobilization was not provided as part of this response.

References:

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Request:

- v. **Describe the potential for the mobilization and conversion of mercury to methylmercury during the construction and operation of the NNL lake.**

Response:

- v. Shell expects that mercury will be mobilized in the compensation lake and fish tissue concentrations will rise above background levels a few years after construction is complete. Without mitigation, mercury is expected to be higher than background for at most 20-30 years. With mitigation, it is expected this timeline will be reduced. Northern pike and walleye will be the most affected species.

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- 33. Regional and cumulative effects on fish populations and habitat productivity not assessed.**

Request:

- i. Assess the regional and cumulative effects on fish populations (including species richness) and habitat productivity of multiple NNL fish habitat compensation projects. Include impacts on:**
 - a. regional fish population and species richness;**
 - b. total effective habitat units (by fish species);**
 - c. productivity of habitat;**
 - d. form of habitat - change from riverine to lacustrine;**
 - e. mercury levels in fish and aquatic systems from NNL projects.**

Response:

- i.**
 - a. The DFO No Net Loss Policy ensures there is no significant impact to regional fish populations due to oilsands development. Habitat units and total productivity after compensation are increased, sportfish populations are increased, and species diversity will be maintained.
 - b. The habitat units will be presented in the draft NNL Plan.
 - c. Habitat productivity will be presented in the draft NNL Plan.
 - d. In terms of the habitat compensation credits, riverine habitat is replaced with lacustrine habitat for the most part. Operators will be creating large areas of riverine habitat similar in quality to the pre-disturbance habitat on the reclaimed landscape although it is not currently considered fish habitat compensation. On closure, regional riverine habitat area will be similar to predisturbance habitat area.
 - e. Regional mercury levels will not be significantly increased although fish tissue mercury levels in specific waterbodies may increase for a time as described in question 29.

References:

RAMP (Regional Aquatics Monitoring Program). 2010. *Regional Aquatics Monitoring Program, 2009 Technical Report*. Prepared for the RAMP Steering Committee. April 2010.

Request:

- ii. **Identify the impact of the cumulative effects noted above on the ACFN's traditional resource use and their Rights. Specifically, identify how the shifts in species and habitat types, along with the time lags and mercury contamination of fish, would affect the ACFN's traditional use and ability to exercise their Rights. Provide documentation to the regulators that these predicted effects have been submitted to the ACFN for verification. Provide documentation that the ACFN have provided this verification.**

Response:

- ii. DFO policy requires that compensation habitat constructed in accordance with *Fisheries Act* 35(2) Authorizations provide greater than one-to-one fish habitat compensation to achieve the objective of no net loss of productive capacity of fish habitats. On a cumulative basis, this is projected to result in increased regional fish populations, especially for sport fish and will maintain the species richness of the region. Shell acknowledges that there will be a period of time before ACFN are able to access functioning compensation habitat to exercise traditional activities related to fish and aquatic resources and this is part of the reason the compensation ratio is greater than 1 to 1. Further, Shell's consultation and EIA suggest that the fish habitat that is being impacted as part of the JME and PRM projects is of marginal quality, and provides a marginal fishery resource. There will be a period of reduced ability to exercise harvesting activities in respect of certain marginal fisheries, which is accommodated by DFO requirements to produce additional amounts of compensation habitat.

Request:

- iii. **Commit to work with the ACFN to develop a contingency plan in the possible case that the NNL plan(s) does not meet regulatory expectations and/or commitments Shell has made to the ACFN, other Rights holders, and other land users.**

Response:

- iii. Shell is committed to providing compensation for all fish habitat in accordance with DFOs regulatory requirements. If DFO deems Shell is deficient and requires more compensation to achieve adequate compensation, Shell would provide that additional compensation. Shell would work with DFO on those requirements and Shell expects that DFO would require consultation as part of that process. Shell currently has no other commitments on fish habitat compensation.

34. Inadequate assessment of impacts from losses of multiple streams in the region.

Request:

- i. Assess the cumulative effects of the loss of the region's many smaller tributary streams on aquatics and hydrology.**

Response:

The cumulative effects of the loss of small tributaries on hydrology have been assessed in terms of increase/decrease in open-water areas and also in terms of flow changes in the downstream receiving streams (Volume 4A, Section 6.4.6.3 of the EIA). A discussion on the effects to aquatics is presented in part ii of this question.

As presented in Volume 4A, Section 6.4.7, the total mine development area for existing and approved projects and the Project is less than 1% of the Athabasca River basin area at Node S24. The Project mine development area represents less than 0.1% of the Athabasca River basin area at Node S24. During mine operation, the predicted maximum increase in the mean annual flows at Node S24 for Application Case will be less than 1.0 m³/s or 0.2% relative to Athabasca River pre-development flows.

After mine closure, the predicted increase in the mean annual Athabasca River flow at Node S24 for Application Case will be less than 3.0 m³/s or 0.5% relative to pre-development flows. The increase due to the Project will be less than 0.05%.

Request:

- ii. Document changes in species richness and quality of habitat, range and populations of affected species, and predicted timeframe(s) to replace these losses in quality and quantity of habitat.**

Response:

- ii. DFO's No Net Loss requirements ensure there is no significant effect on fish habitat. Overall, the compensation habitat provides higher quality habitat, supports higher fish species diversity and sport fish biomass. All of the species that live in the impacted habitat can live in the compensation habitat.**
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1.5 Hydrology

35. Physical dimensions of some large water holding areas unclear.

Requests:

- i. Provide a table summarizing the maximum surface areas, filled water volumes, and timing for the External Tailings Disposal Area, pit lakes, Compensation Lake, and all other water storage areas, in a tabular form.**

Response:

- i. The following table provides storage data for PRM water-containing features. These data are preliminary pending completion of detailed project design, completion of the project No Net Loss Plan and further information on the Phase 2 Framework for the Lower Athabasca River is provided.

Table 34-1

Facility	Area (km ²)	FluidWater Holding Capacity (Mm ³)	First Year of Operation
External Tailings Disposal Area	15.85	111	2018
Pit Lakes	14.6	174	2049
Redclay Compensation Lake	4.0	20	to be determined through NNL process
Raw Water Storage Facility/ Treatment Lake	As required by Phase 2 Water Management Regulation	As required by Phase 2 Water Management Regulation	2018

The size of Redclay Compensation Lake used for EIA assessment is 2.5 km². The conceptual compensation plan submitted as part of EIA application shows a size of 4 km². Recent consultation has presented a more refined conceptual lake size of approximately 3.2 km². However, the required compensation size will be better defined as part of the detailed draft NNL plan Shell is currently completing for the project.

Requests:

- ii. Provide an alternative surface water management scenario where clean water, process-affected water, and fluid tailings are kept separate and managed as three separate functions; include a tabular comparison of surface disturbance, capital, and operating cost implications, and the resultant changes in liability estimates.**

Response:

The current site water management strategies provided in the 2007 EIA application document, include separating and managing clean water and process-affected water streams effectively for maximum operational efficiency as described in Volume 2, Section 10, page 10-2.

Site drainage and runoff that meets water quality standards may be released to the environment (e.g., dewatering flows provided in Volume 4B, Section 6.3, Table 6.3.-15). But some of that water will not meet standards or will be used to offset Athabasca River water requirements.

Process-affected water or water that comes in contact with oil sands and that is not suitable for discharge will be collected within a closed-circuit system and used in the process (e.g., Basal Aquifer water and Pleistocene Channel water, provided in Volume 2, Section 10, Table 10-2).

36. Watercourse flows to the Athabasca River not clearly represented.

Requests:

- i. Re-calculate inflows to Redclay Lake based on each of the inflowing tributaries on a timescale that captures major changes and provides a relevant scenario for changing inflows to the Athabasca River.**

Response:

The hydrological assessment of flow changes to the Athabasca River was based, in part, on a conceptual compensation lake design with anticipated size of roughly 2.5 km² with inflows stemming from Big Creek. Accordingly, changes to Big Creek

and to inflows to the Athabasca River for various critical time snapshots to capture major changes are provided in EIA Volume 4A, Section 6, Table 6.4-20.

Since completing the EIA, Shell has continued to refine its designs for the Redclay Compensation Lake through development of the project's draft No Net Loss Plan (NNLP). The current design, based on ongoing consultation with DFO and stakeholders, suggests a more likely lake size of approximately 3.2 km². However, the final required compensation size will not be available until acceptance of the NNLP by DFO.

Shell recognizes that the final size of the compensation lake will likely differ from that provided in the EIA. However, Shell is confident that the hydrological assessment of flow changes to the Athabasca River will remain comparable, even if the final size of the Redclay Compensation Lake extends to the Redclay Creek watershed, as incremental lake size and additional inflow to Redclay Compensation Lake from Redclay Creek would result in negligible change to associated inflows to Athabasca River.

Requests:

- ii. **Re-calculate inflows to Pierre South Pit Lake based on each of the inflowing tributaries on a timescale that captures major changes and provides a relevant scenario for changing inflows to the Athabasca River.**

Response:

In the EIA assessment, all creeks that contribute inflows to Athabasca have been considered and assessed properly. In pre-development, two major streams are directly contributing inflows to Athabasca River: Eymundson Creek and Pierre River. Asphalt Creek and Unnamed Creek 1 are tributary creeks to Eymundson Creek.

During mine operation, Eymundson Creek and its tributary (Asphalt Creek) will be diverted on the north side of the mine development area through diversion (Ditch C) to Athabasca River from 2016 to 2049. Unnamed Creek will be diverted south to Pierre River diversion channel (Ditch H) during operation around the mine development to Athabasca River.

Changes to inflows to Athabasca River due to diversion of these tributaries around the mine site and due to the effect of mine closed-circuit operations were properly presented in the EIA (Volume 4A, Section 6, Table 6.4-21 and Table 6.4-22) for

time snapshots during mine operation (i.e., Year 2031 and Year 2039 time snapshots).

- Inflows from Ditch C to Athabasca River were compared to pre-development inflows from Eymundson Creek excluding inflows from Unnamed Creek since Unnamed Creek will be diverted south to Ditch H.
- Inflows from Ditch H to Athabasca River were compared to pre-development inflows from Pierre River including inflows from Unnamed Creek since Unnamed Creek will be diverted south to this ditch.

For Year 2049 and Far-future time snapshot, the Pierre South Pit Lake would be part of mine closure feature. Eymundson Creek including its tributaries (Asphalt Creek and Unnamed Creek 1) contributes inflows to Pierre South Pit Lake. Hence, the Application Case outflows from the Pierre South Pit Lake, which is inflows to Athabasca River, were properly compared to pre-development inflows from Eymundson Creek to Athabasca River as provided in EIA Volume 4A, Section 6, Table 6.4-21.

The cumulative inflow changes to the Athabasca River from Eymundson Creek and Pierre River for various critical time snapshots to capture major changes are also provided in EIA Volume 4A, Section 6, Table 6.4-20, Table 6.4-21, Table 6.4-22 and Table 6.4-23.

37. Water withdrawal plans not detailed.

Request:

- i. Describe Shell's plans for water storage and use during times when restrictions are imposed (within and beyond 30 days planned storage).**

Response:

- i. The Phase 2 regulatory requirements are still unknown. However, Shell did agree to the non-concensus recommendation submitted by the P2FC for Phase 2 water management. Shell still supports that recommendation, but Shell's future water management will be driven by the Regulation when it is implemented.

The Phase 2 Regulation is expected to dictate cumulative withdrawals but not each company's share of that cumulative withdrawal. Shell will work with industry to apportion the allowed cumulative withdrawal and stay in compliance with Phase 2 on a week-by-week basis. This will require Shell to build storage or storage equivalent to provide water when access to river water is restricted. Storage equivalent would include

water treatment, ground water use, reduced production and other solutions that keep Shell within its regulatory limits. It should be noted that, on an annual basis, Shell's actual water requirements will remain the same as in the Application.

Request:

- ii. Commit to abide by the lower Athabasca River WMF restrictions, notably during low flow periods.**

Response:

- ii. Shell has a regulatory commitment to comply with the Phase 1 regulation now and the Phase 2 regulation when it comes into effect.

38. Information on open water areas created during operations unclear.

Requests:

- i. Re-calculate open water areas in Table 6.4-19 to account for all new open water areas created during project operations.**

Response:

The open-water areas provided in Table 6.4-19 accounts for all open water areas that are outside the closed-circuit system. The pre-development open-water area is 7.2 km², which includes an open-water area of 2.2 km² for streams and 5.0 km² for ponds and lakes. In 2031, the PRMA project will result in decreased open-water areas for the stream (from 2.2 to 1.85 km²) and for natural ponds and lakes (from 5.0 to 4.05 km²). However, the overall open-water areas for this time snapshot will increase (from 7.2 to 8.4 km²) since additional open-water area of about 2.5 km² is created as part of Redclay Compensation Lake. The temporary open-water areas created within the closed-circuit (such as water storage areas within the External Tailings areas) are not included the analysis since these temporary features will not affect aquatic resources including watershed hydrology.

The size of Redclay Compensation Lake used for EIA assessment is 2.5 km². The conceptual NNL plan submitted as part of EIA application shows a size of 4 km². Recent consultation has presented a more refined conceptual lake size of approximately 3.2 km². However, the required compensation size will be better

defined as part of the detailed draft NNL plan that Shell is currently completing for the project.

Requests:

- ii. Provide the regulators with the information necessary to make a Public Interest Determination.**

Response:

As indicated in 38 (i), all the information related to open water areas are provided in the EIA application.

39. Additional NNL compensation lake water details required.

Request:

Clarify whether water from the Athabasca River required to fill Redclay Lake is included in the requested 55 Mm³/yr. If not, provide details of the timing and quantity of water withdrawals for this purpose.

Response:

Shell does not plan to take water from the Athabasca River to fill Redclay Lake. Redclay Lake would be filled from Big Creek which feeds directly into the lake. A separate water licence will be applied for as necessary in the future.

40. Pit lakes filling information unclear.

Requests:

- i. Revise Table 6.4-21 to separate the time periods of 2049 and the “far future”**

Response:

A revised version of Table 6.4-21, which now separates the time periods of Year 2049 and Far Future, follows. As seen in the revised table, the flow statistics for Year 2049 will be the same as the Far Future.

Updated Table 6.4-21 Effect on the Eymundson Creek Flows for Application Case

Year	Parameter	Pre-Development	Application Case	
		Streamflow Discharge (m ³ /s)	Streamflow Discharge (m ³ /s)	Change Due to the Project (m ³ /s)
2015	Annual Mean Discharge	0.66	0.68	0.017
	Mean Open-Water Discharge ^(a)	1.09	1.12	0.027
	Mean Ice-Cover Discharge ^(a)	0.06	0.067	0.007
	7Q10 Low Flow Discharge	0	0.007	0.007
	10 Year Flood Peak Discharge	18.9	18.9	0.03
2031	Annual Mean Discharge	0.51	0.51	0
	Mean Open-Water Discharge ^(a)	0.839	0.840	0.001
	Mean Ice-Cover Discharge ^(a)	0.048	0.050	0.002
	7Q10 Low Flow Discharge	0	0	0
	10 Year Flood Peak Discharge	14.6	14.9	0.3
2039	Annual Mean Discharge	0.51	0.51	0
	Mean Open-Water Discharge ^(a)	0.839	0.840	0.001
	Mean Ice-Cover Discharge ^(a)	0.048	0.050	0.002
	7Q10 Low Flow Discharge	0	0	0
	10 Year Flood Peak Discharge	14.6	14.9	0.3
2049	Annual Mean Discharge	0.66	0.56	-0.1033
	Mean Open-Water Discharge ^(a)	1.09	0.84	-0.2533
	Mean Ice-Cover Discharge ^(a)	0.06	0.17	0.1067
	7Q10 Low Flow Discharge	0	0.007	0.0067
	10 Year Flood Peak Discharge	18.9	6.0	-12.9
Far Future	Annual Mean Discharge	0.66	0.56	-0.1033
	Mean Open-Water Discharge ^(a)	1.09	0.84	-0.2533
	Mean Ice-Cover Discharge ^(a)	0.06	0.17	0.1067
	7Q10 Low Flow Discharge	0	0.007	0.0067
	10 Year Flood Peak Discharge	18.9	6.0	-12.9

(a) "open-water" season is the period from mid-April to mid-November; "ice-cover" season is the period from mid-November to mid-April.

Requests:

ii. Clarify:

- **The reason for diverting tributary stream water to pit lakes after 2049 (as opposed to routing them directly to the River);**
- **Whether the pit lakes will be filled by 2049;**
- **Whether water quality is expected to be suitable for release from the tributaries and the end pit lakes at that time.**

Response:

The tributary stream flows are required to be diverted to pit lakes to ensure hydrologic sustainability of the lakes over the long-term and during dry years. Pit lakes will provide treatment for the tailings pore-water releases before they are discharged to the Athabasca Rivers.

The pit lakes will be filled over the period from 2039 to 2049 from the Athabasca River in accordance with the applicable restrictions of the Water Management Framework for the Lower Athabasca River, as amended. As discussed in EIA, Vol. 4A, Sec. 6.5.6.2, the pit lake water quality has been modelled, and is predicted to be acceptable for release by this time.

41. Impacts of loss of several mainstem sections of pristine creeks inadequately assessed.

Requests:

Describe the physical aspects of the changes in surface flows, and the physical implications of these changes on remaining waterbodies resulting from stream removals (e.g., flow rates, flow regimes, temperature fluctuations, sediment loads, erosion).

Response:

The effects of changes in surface flows and physical implication of changes in flow regimes were presented in EIA Volume 4A, Section 6.4.6 in terms of parameters such as changes in open-water areas, changes to sediment yield from watershed, changes in sediment concentration, and channel regimes. EIA Volume 4A, Section 6.5.6.3 presents effects on the thermal regime and sediment quality.

42. Impacts of loss of several mainstem sections of pristine creeks on ACFN Rights inadequately assessed.

Requests:

Discuss the impacts on traditional uses and on First Nation's Rights of the loss of the lower portions of tributaries of the Athabasca River within the PRM.

Response:

Fish habitat will be lost due to the PRM development in the lower Pierre River and the lower reaches of Eymundson and Big creeks, all of which are direct tributaries to the Athabasca River. The lower reaches of these watercourses will be lost but will also be fully compensated in the associated constructed diversion channels and compensation habitat as described in the Conceptual Compensation Plan and as required by DFO's No Net Loss policy. More detail of the compensation habitat will be provided in upcoming draft No Net Loss Plan.

Accordingly, impacts on fish habitat, fish diversity, fish abundance and fish health are predicted to be negligible in the Athabasca River, and therefore there are no predicted significant impacts on the ability of Aboriginal groups to exercise Aboriginal rights related to these receptors.

43. Cumulative impacts to the Athabasca Delta not assessed.

Request:

- i. Extend the Regional Study Area (RSA) for surface water hydrology from Embarras Portage to the inflow of Lake Athabasca (i.e., encompass the Athabasca Delta).**

Response:

- i. This question is addressed in PRM Round 1 AENV SIR 34a.

The aquatics RSA was established as the geographical extent in which project activities have the potential to act cumulatively with other development activities to result in measurable effects on surface water quantity and quality, and fish and fish habitat. The aquatics RSA includes the reach of the Athabasca River adjacent to all oil sands mines, extending downstream to the Embarras River upstream of the Athabasca River Delta and Lake Athabasca.

No appreciable water quantity and quality changes were predicted for the Application or Planned Development cases relative to the pre-development or Base Case at Embarras (Node A4), (see EIA, Volume 4A, Aquatic Resources, Section 6.5.7.3,

Table 6.5-22). The negligible surface water quantity and quality, and fish and fish habitat effects predicted in the Athabasca River upstream of the Athabasca River Delta and Lake Athabasca confirmed that the downstream limit of the aquatics RSA was appropriate, and an extension of the study area boundary farther downstream was not considered necessary.

Request:

- ii. Re-calculate the impacts, including those on the Athabasca Delta.**

Response:

- ii. The negligible surface water quantity and quality, and fish and fish habitat effects predicted in the Athabasca River upstream of the Athabasca River Delta and Lake Athabasca confirmed that the downstream limit of the aquatics RSA was appropriate, and an extension of the study area boundary farther downstream was not necessary. Hence, there is no need to re-calculate the impacts, since the impacts to Athabasca Delta are immeasurable.

The CEMA non-consensus Phase 2 recommendation was designed to protect aquatic resources in the Athabasca River. Subsequent to the EIA and as part of the Phase 2 requirements, CEMA has started additional modelling and knowledge gap assessment within the Delta. The 2010 Royal Society of Canada review (Gosselin et al. 2010) agreed that the Phase 2 recommendation will be protective. The combination of the Phase 2 recommendation and adaptive monitoring and management will protect the Athabasca Delta and the predictions of the EIA are valid.

References:

Goselin, P., S. Hrudey, A. Naeth, A. Plourde, R. Therrien, G. Van Der Kraak & Z. Xu (Royal Society of Canada). 2010. *The Royal Society of Canada Expert Panel: Environmental and Health Impacts of Canada's Oil Sands Industry*. December 2010

Request:

- iii. Given the significance of the Delta to the ACFN, commit to provide the predictive results to the ACFN and to seek the ACFN's verification of these predictions based on the TK of the ACFN.**

Response:

- iii. Please see response 43i above. Also, Shell continues to actively participate in the development of the Phase 2 framework monitoring program for the lower Athabasca River which includes several recommended studies in the Delta. The decisions on which recommended programs proceed are expected to be made by the Regulators.

Given its importance to ACFN, Shell would urge ACFN to participate in Phase 2 monitoring. The Phase 2 monitoring program does include a strong community involvement recommendation. That work won't be delivered directly by Shell but will be delivered by CEMA and whatever organization takes on the monitoring that was being conducted by RAMP.

1.6 Air Quality

44. Removal of industrial areas from the assessment is misleading.

Request:

- i. Provide the results of the re-evaluation of the 24-hour and annual averages including the eight highest values previously excluded.**

Response:

- i. A re-evaluation of the 24-hour and annual concentrations including the eight highest hours is provided in the PRM Round 1 SIR ERCB 228.

Overall, the peak 24-hour and annual predictions are slightly higher than the maximum 24-hour and annual predictions; however, none of the maximum concentrations or peak concentrations of SO₂ and NO₂ in the LSA and outside disturbed areas exceed the applicable AAAQOs. The results in the EIA indicated that there are exceedances of AAAQOs for 24-hour and annual NO₂ inside the RSA in the Base Case, Application Case and Planned Development Case; however, these exceedances were not caused by the project emissions. Finally, consideration of peak concentrations instead of maximum concentrations does not change the environmental consequences for air quality.

Request:

- ii. Engage the ACFN to confirm the veracity of the air quality model(s) by comparison with the ACFN's TK.**

Response:

- ii. Shell is confident in the methods used in the Air Quality Assessment as they are based on guidance from the AENV Air Quality Model Guideline and in consideration of TK available for the project. If ACFN possess TK that they feel impacts the choice of methodology, Shell requests that ACFN provide such information along with an indication of how it might change Shell's methods, for Shell's consideration.

Request:

- iii. Commit to submitting the outcome(s) of the above dialogue to regulators.**

Response:

- iii. Shell documents all discussions with ACFN and provides the outcome of consultation to regulators as part of its bi-monthly consultation summaries.
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45. Magnitude classification levels not reflective of air guidelines and standards.

Request:

Reassess the environmental consequences using the higher magnitude ratings for exceedances of the AAAQO to better identify which issues are approaching the environmental limits.

Response:

For 1-hour SO₂, a “negligible” magnitude was assigned if the difference between Application Case and Base Case predictions was less than 1% of the AAAQO (i.e., less than 4.5 µg/m³). A “low” magnitude was assigned if the change was greater than 1% of the AAAQO but the actual predicted concentration was lower than the AAAQO. A “moderate” magnitude was assigned if the predicted concentration was greater than the AAAQO but less than the federal objective (900 µg/m³). A “high” magnitude was assigned if the predicted concentration was greater than the federal objective. Since the change in 1-hour SO₂ predictions between Base Case and Application Case was less than 1% of the AAAQO, it was rated as “negligible”. Therefore, changing the “high” magnitude definition (i.e., lowering it from 900 to 450) would not change the overall environmental consequence.

46. Assessment of secondary pollutants and their impacts deficient.

Request:

Discuss how and what role Shell will play in further research into secondary air pollutants and their impacts on environmental receptors, including health risks.

Response:

The air quality assessment included the formation of secondary particulates (i.e., sulphates and nitrates) through the chemistry algorithm in the CALPUFF model. It was assumed that 100% of the airborne sulphates and nitrates form secondary aerosols and were added to the PM_{2.5} predictions, resulting in potentially conservative estimates of particulate (PM_{2.5}) concentrations.

Given the findings of the human health risk assessment, the wildlife health risk assessment and the air emissions effects assessment, which are both informed with conservatism in the the air modelling, Shell currently has no plans to conduct further research into secondary air pollutants and their associated impacts. However, Shell has committed to continued air quality monitoring in the region and adaptive management to address any unanticipated incremental effects associated with its proposed projects.

47. Potential Acid Input ranking inadequate.

Request:

- i. **Describe the current state-of-knowledge with respect to acid deposition and trends in the region.**

Response:

- i. Extensive research and monitoring of the effects of acid deposition in western Canada and in the Oil Sands Region is currently being conducted through various regional initiatives and academic institutions. For example, the Terrestrial Environmental Effects Monitoring (TEEM) program of WBEA is conducting effects monitoring, wet and dry deposition mapping and model evaluations in the Oil Sands Region (WBEA 2010). The Cumulative Environmental Management Association also funds research relevant to evaluating the effects of acid deposition on aquatic and terrestrial ecosystems.

The RAMP acid sensitive lakes program (RAMP 2010) monitors 50 lakes of varying levels of acid sensitivity in the Oil Sands Region. RAMP evaluates temporal trends in acidification indicators and exceedances of the critical load individually for each lake and collectively by sub-region. The 2009 RAMP results indicate that there has been no apparent change in the degree of lake acidification in the Oil Sands Region since the beginning of monitoring, as shown by very few statistically significant among-year differences, and inconsistent and mostly non-significant temporal trends in acidification indicators among lakes and among variables analyzed. Long-term

average potential for acidification was classified as negligible-low for all sub-regions except for the Birch Mountains, where it was classified as moderate.

Two recent paleolimnological studies funded by CEMA examined a number of lakes in the Oil Sands Region for evidence of recent acidification. Hazewinkel et al. (2008) sampled eight acid sensitive lakes and concluded that there were no recent temporal changes in pH or alkalinity in these lakes, consistent with the results of RAMP. Curtis et al. (2010) evaluated 12 different lakes in the region and concluded that acidification “does not appear to be a widespread problem in northern Alberta”. However, Curtis et al. (2010) provided the first evidence of recent acidification of one lake in the Oil Sands Region, and suggested that small, shallow lakes within peaty catchments are most vulnerable to acid deposition. They also identified the potential for NO_x emissions from oil sands developments to contribute to nutrient enrichment in regional lakes.

Recent studies relevant to acidification effects on soils and vegetation in the Oil Sands Region are summarized below:

- Whitfield et al. (2009) used the Model for the Acidification of Groundwater In Catchments (MAGIC) to predict the response of forest soils at 11 locations in the Oil Sands Region for the period 1900 to 2100, assuming no change or a doubling of sulphur deposition. Results indicate that although acid deposition may result in measurable changes in soil base saturation and soil solution base cation to aluminum (BC:Al) ratio, effects on soils are likely to be limited with a doubling of sulphur deposition.
- Wieder et al. (2010) evaluated atmospheric deposition rates of sulphur and nitrogen, and potential effects on *Sphagnum fuscum* at 10 sites located in ombrotrophic bogs in the Oil Sands Region and reported no effect on *S. fuscum*, and no significant correlations between nitrogen or sulphur deposition rates and distance from the area of intensive oil sands mining, or prevailing wind direction. Wieder et al. (2010) suggested that elevated deposition is restricted to areas closer to mining activity, or immediately downwind of active mines.
- Laxton et al. (2010) evaluated the effect of increased nitrogen deposition since the 1990s in the Oil Sands Region on jack pine at eight TEEM plots representing a gradient of nitrogen exposure. Results indicate that jack pine plots are responding to increased nitrogen exposure in the Oil Sands Region, and that the region is at the very early stage of nitrogen saturation.

Results of additional research into the impacts of sulphur and nitrogen deposition in western Canada are provided in Aherne and Shaw (2010).

Shell is an active participant in the regional initiatives to manage air emissions, including CEMA, which has developed an acid deposition management strategy for the

Oil Sands Region in order to “maintain the chemical characteristics of soils and lakes to avoid adverse effects on ecosystems, plants or animals” (CEMA 2004).

References:

- Aherne, J. and D.P. Shaw, eds. 2010. *Impacts of Sulphur and Nitrogen Deposition in Western Canada*. Journal of Limnology, vol. 69 (suppl. 1).
- CEMA (Cumulative Environmental Management Association). 2004. *Recommendations for the Acid Deposition Management Framework for the Oil Sands Region of North-Eastern Alberta*. Approved February 25, 2004. Fort McMurray, AB. 39 pp.
- Curtis, C.J., R. Flower, N. Rose, J. Shilland, G.L. Simpson, S. Turner, H. Yang and S. Pla. 2010. *Paleolimnological Assessment of Lake Acidification and Environmental Change in the Athabasca Oil Sands Region, Alberta*. In: J. Aherne and D.P. Shaw (ed.). *Impacts of Sulphur and Nitrogen Deposition in Western Canada*. J. Limnol., 69(Suppl.1): 92-104.
- Hazewinkel, R.R.O., A.P. Wolfe, S. Pla, C. Curtis and K. Hadley. 2008. *Have Atmospheric Emissions from the Athabasca Oil Sands Impacted Lakes in Northeastern Alberta, Canada?* Can. J. Fish. Aquat. Sci. 65: 1554-1567.
- Laxton, D.L., S.H. Whatmough, J. Aherne and J. Straker. 2010. *An Assessment of Nitrogen Saturation in Pinus banksiana Plots in the Athabasca Oil Sands Region, Alberta*. In: J. Aherne and D.P. Shaw (ed.). *Impacts of Sulphur and Nitrogen Deposition in Western Canada*. J. Limnol., 69(Suppl.1): 171-180.
- RAMP (Regional Aquatics Monitoring Program). 2010. *Regional Aquatics Monitoring Program, 2009 Technical Report*. Prepared for the RAMP Steering Committee. April 2010.
- WBEA (Wood Buffalo Environmental Association). 2010. *Annual Report 2009*. Fort McMurray, AB.
- Whitfield, C.J., J. Aherne and S.H. Whatmough. 2009. *Modelling Soil Acidification in the Athabasca Oil Sands Region, Alberta, Canada*. Environ. Sci. Technol. 43: 5844-5850.
- Wieder, R.K., D.H. Vitt, M. Burke-Scoll, K.D. Scott, M. House and M.A. Vile. 2010. *Nitrogen and Sulphur Deposition and the Growth of Sphagnum fuscum in Bogs of the Athabasca Oil Sands Region, Alberta*. In: J. Aherne and D.P. Shaw (ed.). *Impacts of Sulphur and Nitrogen Deposition in Western Canada*. J. Limnol., 69(Suppl.1): 161-170.

Request:

- ii. **Explain why a 12% increase above Base Case in the area predicted to exceed the 1.0 keq/ha/yr Potential Acid Input is ranked as negligible. Describe the environmental impact and Shell's assessment of the significance of this predicted increase.**

Response:

- ii. The areas above specific thresholds (i.e., 1.0 keq/ha/yr) shown in EIA Volume 3, Section 3.4.4.2 were only provided for presentation purposes. The thresholds are from the Clean Air Strategic Alliance acid deposition framework and are not effects-based. As stated in EIA Volume 3, Section 3.4.4.3, the impact classification for Potential Acid Input (PAI) was completed based on the management framework developed for use in the Oil Sands Region by CEMA, which incorporates the potential effects on waterbodies, soils and vegetation. The PAI predictions made in the air quality assessment were carried forward to the Air Emissions Effects on Ecological Receptors section of the EIA (Volume 3, Section 5.5) where the impact classification was completed. A summary of the EIA acidification discussion is provided below. Details of the assessment methods are provided in EIA Volume 3, Section 5.5.2.

The residual impact classification of terrestrial vegetation and wetlands potentially affected by acidification due to the Project is presented in Table 5.5-21 in EIA, Volume 3, Section 5.5.5. Acidification presents an indirect effect to vegetation; therefore, the effect of acidifying emissions on vegetation is assessed using soil critical loads and soil net PAI. There is an overall decrease to vegetated areas predicted to exceed soil net PAI from the Base Case to the Application Case. This decrease is attributed to the modelled location of the Jackpine mine fleet, which was relocated in the Application Case, rather than a decrease in emissions. A total of less than 1% of vegetated areas of the Terrestrial Assessment Study Area (TASA) were expected to be affected by PAI under the Application Case, representing a less than 1% decrease from the Base Case. Due to the limited relative contribution, the residual impacts of the Project on acidification (PAI) to terrestrial vegetation and wetlands were therefore considered negligible.

48. Additional details in odour assessment of ACFN locations required.

Request:

Provide additional information including predicted frequency, duration and odour species on the predicted impacts of increased foul odour experiences at the Poplar Point Reserve, and on the ACFN's traditional use.

Response:

Odour frequency predictions were provided for the Poplar Point Reserve in EIA Volume 3, Section 3.4.5. The odour predictions were revised and are provided in PRM Round 1 SIRs, Volume 1, Section 7.2, Tables 1.1-2 and 1.1-3. The odourous compounds used in the assessment are provided in EIA Volume 3, Section 3.4.5, Tables 3.4-26 and 3.4-27. All of the cabins included in the tables are located within the ACFN traditional lands and are considered representative of what odours may be experienced in different portions of the ACFN traditional lands.

The results indicate that the Project emissions increase the predicted maximum 1-hour odour levels by up to 0.3%. The Project emissions also increase the number of hours that peak odour events occur at all of the cabins assessed, with the exception of one cabin. The maximum change in the number of hours of peak odour events is 2.6% of the time. Overall, the odour predictions show a minimal increase in the number of hours in which odour levels exceed odour thresholds.

Table 3.4-28 Comparison of Base Case and Application Case 1-Hour Odour Predictions

Community	Base Case		Application Case		Change Due to Project ^(a) [%]
	Hours >Threshold ^(a)	Fraction of Time ^(a) [%]	Hours >Threshold ^(a)	Fraction of Time ^(a) [%]	
Anzac	0	0.0	0	0.0	0.0
Conklin	0	0.0	0	0.0	0.0
Fort Chipewyan	0	0.0	0	0.0	0.0
Fort McKay	29	0.3	32	0.4	0.0
Fort McMurray	0	0.0	0	0.0	0.0
Janvier/Chard (IR 194)	0	0.0	0	0.0	0.0
Clearwater (IR 175)	0	0.0	0	0.0	0.0
Namur River (IR 174A)	0	0.0	0	0.0	0.0
Poplar Point (IR 201G)	0	0.0	0	0.0	0.0
Cabin A	0	0.0	1	0.0	0.0
Cabin B	0	0.0	0	0.0	0.0
Cabin C	0	0.0	0	0.0	0.0
Cabin D	0	0.0	1	0.0	0.0
Cabin E	0	0.0	1	0.0	0.0
Cabin F	0	0.0	1	0.0	0.0
Cabin G	131	1.5	134	1.5	0.0
Cabin H	8	0.1	10	0.1	0.0
Cabin I	7	0.1	7	0.1	0.0
Cabin J	133	1.5	157	1.8	0.3
Cabin K	130	1.5	150	1.7	0.2

Community	Base Case		Application Case		Change Due to Project ^(a) [%]
	Hours >Threshold ^(a)	Fraction of Time ^(a) [%]	Hours >Threshold ^(a)	Fraction of Time ^(a) [%]	
Cabin L	0	0.0	1	0.0	0.0
Descharme Lake, SK	0	0.0	0	0.0	0.0
La Loche, SK	0	0.0	0	0.0	0.0
Oil Sands Lodge	127	1.4	138	1.6	0.1
PTI Camp	158	1.8	158	1.8	0.0

^(a) Calculated on a yearly basis.

Table 3.4-29 Comparison of Base Case and Application Case Peak Odour Predictions

Community	Base Case ^(a)		Application Case ^(a)		Change Due to Project ^(b) [%]
	Hours >Threshold ^(b)	Fraction of Time ^(b) [%]	Hours >Threshold ^(b)	Fraction of Time ^(b) [%]	
Anzac	0	0.0	0	0.0	0.0
Conklin	0	0.0	0	0.0	0.0
Fort Chipewyan	0	0.0	0	0.0	0.0
Fort McKay	414	4.7	440	5.0	0.3
Fort McMurray	1	0.0	1	0.0	0.0
Janvier/Chard (IR 194)	0	0.0	0	0.0	0.0
Clearwater (IR 175)	0	0.0	0	0.0	0.0
Namur River (IR 174A)	0	0.0	0	0.0	0.0
Poplar Point (IR 201G)	0	0.0	0	0.0	0.0
Cabin A	9	0.1	105	1.2	1.1
Cabin B	10	0.1	10	0.1	0.0
Cabin C	14	0.2	15	0.2	0.0
Cabin D	22	0.3	33	0.4	0.1
Cabin E	23	0.3	33	0.4	0.1
Cabin F	22	0.3	41	0.5	0.2
Cabin G	306	3.5	325	3.7	0.2
Cabin H	150	1.7	214	2.4	0.7
Cabin I	148	1.7	159	1.8	0.1
Cabin J	564	6.4	591	6.7	0.3
Cabin K	575	6.6	609	7.0	0.4
Cabin L	81	0.9	307	3.5	2.6
Descharme Lake, SK	0	0.0	0	0.0	0.0
La Loche, SK	0	0.0	0	0.0	0.0
Oil Sands Lodge	698	8.0	721	8.2	0.3
PTI Camp	978	11.2	992	11.3	0.2

- (a) Calculated on a yearly basis.
 - (b) Values are based on a peaking factor of 2, which is appropriate when receptors are within 2 and 5 km of the same source and is conservative for receptors beyond 5 km from the source.
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49. Ground-level ozone poorly assessed.

Request:

Include a rigorous evaluation of the oxidizing potential of the regional air shed, including causal factors, synergistic effects, transport mechanisms and fates, by odour species.

Response:

The potential for ozone formation in the area is being assessed on a regional basis through WBEA and CEMA, rather than on a project-by-project basis. Environment Canada has performed ozone modelling assessments in the region, the latest results being presented in *Modelling of Ozone Levels in Alberta: Base Case, Sectoral Contributions and a Future Scenario* (Environment Canada 2007).

In the EIA, estimates of ozone precursor emissions were included (EIA Volume 3, Section 3.4.5). The Project was estimated to contribute approximately 3% to ozone precursor emissions in the region. On this basis, the Project's estimated increase in ozone precursor emissions would likely result in an increase of less than 1 ppb in peak-hourly ozone concentrations. Shell is participating in the development of a regional management framework for ozone through CEMA's Air Working Group (AWG).

References:

Environment Canada. 2007. *Modelling of Ozone Levels in Alberta: Base Case, Sectoral Contributions and a Future Scenario*. Air Quality Science Unit, Edmonton, AB. December 2007.

50. Climate change impact classification lacking.

Request:

Provide a comparison of the relative emission intensities (per unit of production) of this project, including off-site upgrading, with other oil sands projects.

Response:

A comparison of greenhouse gas emission intensities with similar projects was provided in Volume 3, Section 3.4.8 of the EIA. Since the Project does not include an upgrader, proposed projects with only bitumen production were included. Table 50-1 provides the greenhouse gas emission intensities for projects with only bitumen production.

Since the Scotford Upgrader is not part of this Project application, its GHG emissions were not included in the comparison.

Table 50-1 Comparison of Greenhouse Gas Emission Intensity

Project	Bitumen Capacity [bbl/cd]	GHG Intensity - Direct [kg/bbl]	GHG Intensity - Indirect [kg/bbl]	Total GHG Intensity [kg/bbl]
Muskeg River Mine Expansion	270,000	28.8	14.2	43.0
Jackpine Mine – Phase 1	200,000	32.0	0.3	32.3
JME – Scenario 1 (with AER)	100,000	58.3	0.4	58.6
PRM – Scenario 1 (with AER)	200,000	45.6	1.1	46.6
JME – Scenario 2 (with gas-fired cogeneration)	100,000	32.0	0.4	32.3
PRM – Scenario 2 (with gas-fired cogeneration)	200,000	29.8	1.1	30.9
Suncor Fort Hills Mining Project	190,000	n/a	n/a	38
Imperial Kearn Oil Sands Project	300,000 to 340,000	n/a	n/a	40

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

n/a = Not available.

51. Cumulative effect of multiple projects on regional air quality inadequately assessed.

Request:

- i. Assess and provide an analysis on the cumulative effects of the growth of air emissions in the region using a pre-industrial baseline and projecting this out by 100 years – (i.e., from 1965 to 2065).

Response:

- i. As stated in the Introduction section of the JME Technical Review response document, a pre-industrial baseline scenario has not been assessed. All existing, approved and publicly disclosed planned projects available at the time of the preparation of the EIA were included in the air quality assessment. The full timeline of the Project was considered in the assessment and some of the planned projects are projected to operate into the 2050s and 2060s. It is difficult to determine the future emissions from these projects due to many uncertainties; however, the best estimated maximum emissions were used in the air quality assessment to provide the reasonable worst case effects on air quality.

Request:

- ii. **Provide a summary table of the projects included in the various assessment cases with their projected emissions listed over the same time frame as above.**

Response:

- ii. The regional projects included in the Base Case and Application Case are provided in EIA Volume 3, Section 3.3.1, Table 3.3-1. The regional projects included in the Planned Development Case are provided in EIA Volume 3, Section 3.5.2, Table 3.5-1. The Base Case and Application Case emissions used in the assessment represent the maximum emissions over the approved life of each project. The PDC emissions are the best estimate of the maximum values based on available information.

The projected emissions over the timeframe requested have not been provided due to the high uncertainty in the number of new projects that will be operating in the region up to 2065 and their estimated emissions. Including projected emissions up to 2065 is also of limited value in terms of assessing the impacts of this project in accordance with the Terms of Reference and CEAA.

Information on air emissions in the Oil Sands Region is available from Alberta Environment and other agencies such as Strategy West Inc.

1.7 Wildlife

52. Waterfowl species not selected as KIRs.

Request:

Provide an assessment of the impacts to at least one species of waterfowl, such as the mallard.

Response:

The mallard duck is ranked as “Secure” in the province of Alberta (ASRD 2006, website). In the boreal forest, preferred habitat during the breeding season includes vegetated and fertile wetlands with some open water and high shoreline irregularity (Merendino and Ankney 1994). Fast moving water is avoided but quiet portions of rivers and margins of small and large lakes are also used (Semechuck 1992). Suitable breeding habitat appears to only be limited by the presence of shallow open water feeding areas and the availability of suitable nest sites, which include relatively dry ground with tall vegetation for cover (Semenchuk 1992).

To assess the impacts of the Project on mallard duck habitat, change in area of regional land cover classes (RLCCs) and wetlands/waterbody types were evaluated in the RSA and LSAs, respectively. Regional land cover classes that include potential mallard duck habitat include the water and the non-treed wetlands RLCCs. At the LSA scale, changes in area of graminoid fen (FONG), graminoid marsh (MONG), shallow open water (WONN), rivers and lakes were evaluated.

There will be a 8,814 ha (3%) loss of mallard duck habitat in the RSA during Project operations. At Closure in the RSA, mallard duck habitat will increase by 1,911 ha (1%) from 278,903 ha at Base Case to 280,814 ha at Closure.

There will be a 3,600 ha (72%) loss of mallard duck habitat in the LSAs during Project operations. At Closure in the LSAs, mallard duck habitat will increase by 3,342 ha (67%) from 5,021 ha at Base Case to 8,364 ha at Closure.

After reclamation, a positive, high magnitude effect is predicted at the LSA scale that is beyond regional in extent, long term in duration and high frequency. The environmental consequences for mallard duck habitat will remain high at the LSA scale and negligible at the RSA scale after reclamation.

Impacts to mallard duck abundance and movement are expected to be the same as impacts assessed for yellow rails. Therefore, environmental consequences of the Application Case for mallard duck abundance are predicted to be low at the LSA scale and negligible at the RSA scale after mitigation (Volume 5, Section 7.5.3.2). The environmental consequences of the Application Case for mallard duck movement are predicted to be low at the LSA and RSA scales (Volume 5, Section 7.5.4.1). At PDC, environmental consequences for mallard duck abundance and movement are predicted to be negligible and low, respectively (Volume 5, Section 7.6.3.1).

The potential risks posed to waterfowl were assessed in the Wildlife Health Risk Assessment (WHRA) (see EIA Volume 3, Section 5.4). The WHRA characterized risks for the mallard and great blue heron by considering the potential changes in air quality, water quality, soil quality and food quality (i.e., dietary items such as benthic invertebrates, aquatic and terrestrial plants for mallards and fish for great blue heron). The uptake of persistent and bioaccumulative chemicals by waterfowl was then carried forward to the

human health risk assessment, wherein people (including those residing in the Peace-Athabasca Delta) were assumed to eat the potentially-affected waterfowl (i.e., mallard).

Risks to waterfowl associated with changes to the water quality were based solely on impacts related to process-affected waters and did not consider the direct exposure of waterfowl to the external tailings disposal areas. As described in the EIA, effects resulting from waterfowl interactions with tailings ponds will be reduced through the implementation of a bird deterrent system that will employ radar-activated scare cannons (see Section 7.5.3.2, Volume 5 of the EIA). As such, direct exposure to the tailings ponds was not assessed in the WHRA.

References:

- ASRD (Alberta Sustainable Resources Development). 2006. *The General Status of Alberta Wild Species 2005*. Alberta Sustainable Resource Development, Fish and Wildlife Service Division.
<http://www.srd.alberta.ca/BioDiversityStewardship/SpeciesAtRisk/GeneralStatus/StatusOfAlbertaWildSpecies2005/Search.aspx>. Accessed January 20, 2011.
- Merendino, M.T. and C.D. Ankney. 1994. *Habitat use by Mallards and American Black Ducks breeding in central Ontario*. Condor 96:411-421.
- Semenchuk, G.P. 1992. *The Atlas of Breeding Birds of Alberta*. Federation of Alberta Naturalists. Edmonton, AB. 393 pp.
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53. Gaps in wildlife baseline surveys.

Request:

Address the wildlife baseline survey gaps identified in the discussion above. Given the significance of the wildlife to the ACFN's traditional resource use and Treaty and Aboriginal rights, commit to provide the predictive results to the ACFN and to seek the ACFN's verification of these predictions based on the TK of the ACFN.

Response:

Breeding birds were surveyed to describe species occurrence, relative abundance, habitat use and classification of birds within the various habitat types (i.e., ecosite phases and wetlands types) in the JME LSA (Golder 2007a). In the JME LSA, a total of 165 counts were conducted over 22 ecosite phases and wetlands types (Golder 2007a).

Bat surveys were conducted to describe species occurrence, relative activity and habitat preferences of bats within the various ecosite phases and wetlands types in the JME LSA

(Golder 2007b). In the JME LSA, 58 call detection stations were surveyed in 15 ecosite phases and wetlands types (Golder 2007b).

Breeding bird and bat survey locations were distributed throughout the JME LSA in a wide range of ecosites phases and wetlands types, including within riparian zones of the Muskeg River. The sampling design and level of effort for these surveys was sufficient to provide the data necessary to characterize the environmental setting in the LSA for breeding birds and bats.

References:

Golder (Golder Associates Ltd.). 2007a. *Wildlife and Wildlife Habitat Setting Report for the Jackpine Expansion and Pierre River Mining Areas Project*. Prepared for Shell Canada Energy. Calgary, AB. Submitted December 2007.

Golder. 2007b. *Terrestrial Environmental Setting Report for the Jackpine Expansion and Pierre River Mining Areas Project*. Prepared for Shell Canada Energy. Calgary, AB. Submitted December 2007.

54. PVA and TK information conflicting.

Request:

Address why Shell has disregarded the TK data that contradicts its modelled predictions.

Response:

Shell did not disregard TK data. Available TK information was integrated into the EIA as described in Volume 5 Section 1.3.7 and in Section 5.2.3 in the Wildlife and Wildlife Habitat Environmental Setting Report. However, TK data is anecdotal in nature cannot be used in a quantitative modelling exercise.

Shell is confident in predictions regarding the potential effects of the Project on wildlife resources. The models used for many of the species are based on direct empirical data from the Oil Sands Region (e.g., moose, Canada lynx, fisher).

The PVA predicts a 2% decline in the carrying capacity of the RSA for moose from the Base Case to the Application Case for the JME and PRM LSAs, and a 9% decline from the Base Case to the PDC (EIA, Volume 5, Appendix 5-V, Section 3.3.1). However, this reduction in the carrying of the RSA is unlikely to significantly affect moose abundance because moose populations in the RSA are believed to be well below carrying capacity.

Moose populations are usually below carrying capacity of the habitat (i.e., the food-limited population density equilibrium) because of the effects of factors such as predation, competition, and human harvest (PRM Round 2 SIR 64a). Crete (1987) and Messier (1994) believed the North American food-limited carrying capacity of moose to be 2.0 moose/km². However, the winter moose density on the JME LSA was estimated to be 0.22 moose/km² during baseline surveys (Golder 2007). More recently, surveys by ASRD in Wildlife Management Units (WMUs) 530 and 531, which make up most of the RSA, have predicted densities of 0.06 moose/km² (± 0.02 moose/km²) and 0.04 moose/km² (± 0.01 moose/km²), respectively (ASRD 2009). This, along with available Traditional Knowledge (TK) suggests a decline in the moose population in the RSA that is occurring irrespective of development of the JME and PRM LSAs.

Two factors that may explain the declining moose population within the RSA, despite sufficient habitat to support higher population densities, are predation and human harvest. Licensed harvest is controlled by a limited entry draw in WMU 531, and harvests over the last several years appear to have been occurring at sustainable levels (ASRD 2009). The contributing effects of predation and unlicensed harvest are unknown. Based on habitat quality and availability assessments alone, the moose population remains well below carrying capacity (T. Powell, ASRD, personal communication). As such, the development of the JME and PRM LSAs are unlikely to have a significant environmental effect on moose abundance in the RSA.

Regarding uncertainty in the PVA modeling, uncertainty is always present in the estimates of survival rates, fecundity rates and population density estimates used in population viability analyses (PVAs; JME Round 1 SIR 438a, PRM Round 2 SIR 62c). Due to this uncertainty, the general consensus among population ecologists is that relative results of PVA, either from sensitivity analyses or comparisons among landscape scenarios, are more reliable for assessing effects than absolute results such as predicted population densities (McCarthy et al. 2003; Schtickzelle et al. 2005). Shell has therefore not based predictions of environmental consequences on predicted moose population densities, but rather by using a comparison of PVA predictions between landscape scenarios, as well as professional judgment.

References:

- ASRD (Alberta Sustainable Resource Development). 2009. *WMU 531 Aerial Moose (Alces alces) survey, February 2009*. 25 pp.
- Crete, M. 1987. *The impact of sport hunting on North American moose*. Swedish Wildlife Research Supplement 1:553-563.
- Golder (Golder Associates Ltd.). 2007. *Terrestrial Environmental Setting Report for the Jackpine Expansion and Pierre River Mining Areas Project*. Prepared for Shell Canada Energy. Calgary, AB. Submitted December 2007.

McCarthy, M.A., S.J. Andelman and H. P. Possingham. 2003. *Reliability of Relative Predictions in Population Viability Analyses*. Conservation Biology 17: 982-989.

Messier, F. 1994. *Ungulate population models with predation: a case study with the North American moose*. Ecology, 75: 478-488.

Schtickzelle, N., M.F. Wallis De Vries and M. Baguette. 2005. *Using Surrogate Data in Population Viability Analysis: The Case of the Critically Endangered Cranberry Fritillary Bitterfly*. Oikos 109: 89-100.

Personal Communication

55. Validity of habitat models questionable.

Request:

- i. Discuss the potential repercussions of ignoring TK and field data and relying on inaccurate wildlife habitat modelling on traditional use and Treaty and Aboriginal rights.**

Response:

- i. With respect, Shell has not ignored TK or field data, and Shell believes its habitat modelling is the best predictive tool for determining the effects of the project on wildlife habitat. While ACFN may disagree with the modelling, disagreements between reasonable EIA practitioners regarding EIA methodologies does not have repercussions on the significance of impacts to the exercise of ACFN's traditional activities. To the extent ACFN believe that they have further TEK or TLU information that contradicts or call into questions Shell's EIA conclusions regarding moose habitat, and how that information translates into impacts on the exercise of Aboriginal rights, Shell encourages ACFN to provide that information to Shell and the Joint Review Panel.

Request:

- ii. Consider modelling calving/post-calving habitats for moose.**

Response:

- ii. A winter habitat suitability model for moose is sufficient for conducting an appropriate cumulative effects assessment for the effects of the Project on this species. Winter is generally a time of hardship for moose, and it is not uncommon to focus habitat

management efforts on delineating and preserving high quality winter habitat, which may be limiting populations.

Cumulative effects on moose habitat and populations were assessed conservatively at the RSA scale for the PDC, which does not take reclamation into account. In the PDC, environmental consequences for the effects of the Project and planned projects on moose abundance, habitat, and movement were assessed as negligible, moderate, and low, respectively (EIA, Volume 5, Section 7.6.3).

56. Loss of riparian habitat may be underestimated.

Request:

- i. Reassess riparian habitat losses based on accepted scientific criteria (not just the 100 meter mapping offset).**

Response:

- i. Riparian areas are defined based on scientific criteria, most notably the vegetation type adjacent to open water. Development of a riparian layer for analysis was done in two steps. In the first step, all waterbodies (i.e., rivers, streams, lakes and ponds) available from AltaLIS at a 1:20,000 scale were first buffered 100 m from the edge of open water (Terrestrial Vegetation, Wetlands and Forest Resource Environmental Setting Report [ESR], Section 3.3.6.1; Golder 2007). While the width of a riparian zone varies according to topography and hydrologic regime, the 100 m buffer zone criteria was assumed to represent a maximum riparian zone width within the region. The buffer zone was overlaid onto the regional land cover classification map for the RSA-level assessment, and ecosite phase and wetlands types map for the LSA-level assessments. Only areas with vegetation classes and types within the buffer zone classed as having riparian potential were classed as riparian habitat (Terrestrial Vegetation, Wetlands and Forest Resource ESR, Section 3.3.6.1; Golder 2007). In the second step, all riparian habitat polygons less than 0.1 ha were removed. These polygons were not considered to represent effective riparian habitat. Other polygons that may have been fragmented by roads or seismic lines, for example, but did occur within a riparian zone were kept as riparian habitat.

Vegetation types with the potential to support riparian communities within the LSAs are described in Beckingham and Archibald (1996), and consist of the following ecosites phases and wetlands types (Terrestrial Vegetation, Wetlands and Forest Resource ESR, Section 3.3.6.1; Golder 2007):

- Central Mixedwood Natural Subregion Ecosite Phases:

- dogwood balsam poplar-aspen (e1);
- dogwood balsam poplar-white spruce (e2);
- dogwood white spruce (e3);
- horsetail balsam poplar-aspen (f1);
- horsetail balsam poplar-white spruce (f2);
- horsetail white spruce (f3); and
- Labrador tea/horsetail white spruce-black spruce (h1).
- Athabasca Plain Natural Subregion Ecosite Phases:
 - willow/horsetail aspen-white birch-balsam poplar (e1);
 - willow/horsetail aspen-white spruce-black spruce (e2); and
 - willow/horsetail white spruce-black spruce (e3).
- Vegetation Types Found in Both Natural Subregions:
 - meadow (Me);
 - shrubland (Sh);
 - forested fen (FFNN);
 - graminoid fen (FONG);
 - shrubby fen (FONS);
 - patterned fen (FOPN);
 - wooded fen with internal lawns (FTNI);
 - wooded fen (FTNN);
 - marsh (MONG);
 - shrubby swamp (SONS);
 - wooded swamp (STNN); and
 - sand.

Vegetation classes with the potential to support riparian communities within the RSA were translated from their LSA-scale equivalent and consisted of the following regional land cover classes (Terrestrial Vegetation, Wetlands and Forest Resource ESR, Section 3.3.6.1; Golder 2007):

- coniferous white spruce;
- deciduous aspen-balsam poplar;
- mixedwood aspen-white spruce;
- non-treed wetlands; and

- treed fen.

References:

Beckingham, J.D. and J.H. Archibald. 1996. *Field Guide to Ecosites of Northern Alberta*. Natural Resources Canada, Northern Forestry Centre, Northwest Region. Special Report 5. Edmonton, AB. 516 pp.

Golder (Golder Associates Ltd.). 2007. *Terrestrial Vegetation, Wetlands and Forest Resource Setting Report for the Jackpine Expansion and Pierre River Mining Areas Project*. Prepared for Shell Canada Energy. Calgary, AB. Submitted December 2007.

Request:

- ii. **Discuss additional mitigation and compensation measures that could offset permanent riparian habitat losses.**

Response:

ii. The Jackpine Mine Expansion EIA Update (May 2008) assesses the impact of changes to the area of riparian habitat; the magnitude of the change was found to be low in a negative direction, with an environmental consequence that was negligible within the LSA, and low within the RSA. On this basis, Shell is not planning on providing specific mitigation measures for riparian areas over and above the closure plan presented in Appendix II (Shell 2008).

Shell will design the closure landscape to provide opportunities for riparian shrublands and for ecosite types that are predominantly transitional riparian (g and h ecosites) or contain a mix of riparian, wetland and upland types (c ecosite) to evolve where the hydrology and drainage patterns of the final topography allows. The closure landscape will be designed to support riparian communities along closure drainage channels, wetlands and water bodies where the hydrological regime supports riparian soil moisture requirements. Riparian shrubland planting prescriptions (i.e., Sh2 and Sh3) will be used within a minimum 35 m buffer surrounding closure drainage channels and riparian communities are expected to evolve on the closure landscape over time.

References:

Shell (Shell Canada Limited). 2008. *Application for Approval of the Jackpine Mine Expansion & Pierre River Mine Project Environmental Impact Assessment Update*. Submitted to the Energy Resources Conservation Board and Alberta Environment. May 2008.

57. Wildlife movement along the Athabasca River will be restricted.

Requests:

- i. Discuss the data available with respect to wildlife movement in various widths of wildlife corridors in the region.**

Response:

Findings from monitoring programs that have been implemented in the Oil Sands Region are discussed here. These include:

- Shell Muskeg River Mine (Golder 2001a),
- Shell Jackpine Mine – Phase 1 (Golder 2009),
- Canadian Natural Horizon (Golder 2007)
- Suncor (Golder 2000; Golder 2001b) and Suncor (2004, 2005 and 2006), and
- corroboration from peer-reviewed literature.

Winter wildlife-track count and camera surveys were conducted in the Muskeg River Mine area to determine wildlife use along the Muskeg River, Jackpine Creek and the Athabasca River. The data indicate that most species are using these corridors.

As stated in EIA Appendix 5-5, Section 3.1.2, page 4, a wildlife corridor monitoring program is being conducted for the Canadian Natural Horizon Project. The program consists of collecting wildlife abundance and species composition data in two study areas, an upland area distant from the Athabasca River and a corridor study area immediately adjacent to the river, using winter track counts from January to March and remote cameras during the snow-free seasons (Golder 2007). The monitoring is designed to assess the importance of the river valley to wildlife relative to upland areas further inland from the river.

Preliminary winter tracking results from the Canadian Natural Horizon monitoring project indicate that species composition and abundance indices were similar between the corridor and upland study areas for all species, except for moose. Moose were recorded only along the Athabasca River. In addition, more moose photos were taken in the corridor study area throughout the year. However, there

were twice the number of remote camera wildlife observations in the uplands than in the corridor study area, and the total number of species detected in the upland study area was larger than the number of species detected in the corridor study area. For the most part, differences between the two areas were not statistically significant.

The Terrestrial and Riparian Organisms, Lakes and Streams (TROLS) Project was initiated to research the impacts of forested buffers and their practical application to preserving the integrity of aquatic and terrestrial communities in the boreal forests of western Canada. The results of this six-year research program have indicated that buffers of 20 to 100 m did not function as adequate reserves for forest-dependent bird species, whereas 200 m buffers were effective in this regard (Hannon et al. 2002).

Large mammal use of long, narrow corridors with restricted widths has been documented outside of northeastern Alberta. As stated in EIA Appendix 5-5, Section 2, page 2, Beier (1995) documented cougar use of 400-m-wide corridors in southern California for distances less than 7 km, with bottlenecks as narrow as 3.3 m at road underpasses. Human use in this example was high, a factor that substantially reduces the likelihood of wildlife use. Both the Athabasca River corridor and the California corridor have land below the edge of an escarpment, reducing the effects of disturbance emanating from above.

Furthermore, in several locations along the Athabasca River, a narrow channel separates the shoreline from relatively large islands. For example, Sled Island is nearly 1 km wide and more than 3 km long. These islands might be used seasonally by many species of wildlife, such as white-tailed deer, moose, wolves and black bears, effectively increasing the width of the remnant corridor for them. Sections of the Pierre River Mine, over a total distance of about 5 km, will approach the 250 m buffer along the Athabasca River. These sections are, on average, about 15 to 30 m above the water's edge, and the difference in elevation might reduce the effects of disturbance in the corridor from the mine.

Based on the available corridor monitoring and wildlife habitat data, peer-reviewed literature and the specific environmental conditions between the Pierre River Mine development area and the Athabasca River, a 250 m setback for the project is considered an appropriate balance between resource recovery and maintaining effective wildlife movement.

References:

- Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. *Journal of Wildlife Management* 59(2):228-237.

- Golder (Golder Associates Ltd.). 2000. Suncor Millennium and Steepbank Mine Projects Wildlife Monitoring Program & Wildlife Assessment Update 2000. Submitted to Suncor Energy Inc., Oil Sands. Fort McMurray, AB. 32 pp. + Appendices.
- Golder. 2001a. Lease 13 West Albian Sands Winter Track Count Surveys to Investigate Potential Wildlife Movement Corridors. Prepared for Albian Sands Energy Inc. Fort McMurray, AB. 72 pp. + Appendices.
- Golder. 2001b. Suncor Millennium and Steepbank Mine Projects Winter Wildlife Track Count Surveys 2001: Year Three. Prepared for Suncor Energy Inc. Fort McMurray, AB. 46 pp. + Appendices.
- Golder. 2007. Canadian Natural Horizon Wildlife Corridor Monitoring Program – 2006 Data Report. Prepared for Canadian Natural, Calgary. 5 March 2007.
- Golder. 2009. Shell Jackpine Mine-Phase 1 Wildlife Corridor Monitoring Year 3 Annual Report 2008. Prepared for Shell Canada Ltd. Fort McMurray, AB.
- Hannon, S.J., C.A. Paszkowski, S. Boutin, J. DeGroot, S.E. Macdonald, M. Wheatley and B.R. Eaton. 2002. Abundance and Species Composition of Amphibians, Small Mammals, and Songbirds in Riparian Forest Buffer Strips of Varying Widths in the Boreal Mixedwood of Alberta. Canadian Journal of Forestry Research. 32:1784-1800.
- Suncor (Suncor Energy Inc.) 2004. Wildlife Monitoring Program and Wildlife Assessment Year 1999-2003. Prepared for Suncor Energy Inc. Fort McMurray, AB.
- Suncor. 2005. Wildlife Monitoring Program and Wildlife Assessment Year 2004. Prepared for Suncor Energy Inc. Fort McMurray, AB.
- Suncor. 2006. Wildlife Monitoring Program and Wildlife Assessment Year 2005. Prepared for Suncor Energy Inc. Fort McMurray, AB.

Requests:

- ii. **Discuss the impacts of restricted wildlife movements along the Athabasca River on traditional use and the ACFN's Rights.**

Response:

EIA Volume 5, Section 7.5.5 describes the effects of the Project on wildlife movement. EIA Volume 5, Section 8.1.1 describes the effects of the Project on traditional use including the use of wildlife. The overall conclusion of the wildlife impact assessment was that the potential effects were low to negligible. Accordingly, Shell does not expect any significant adverse impacts to the exercising of ACFN's Aboriginal rights due to changes in wildlife movement.

58. Research and data directly applicable to wildlife lacking.

Request:

- i. Discuss how the lack of field research and toxicity reference data on wildlife may affect the validity of the wildlife health assessment.**

Response:

- i. Hull (2010) report that extrapolating between species is acceptable. Due to the near absence of toxicity data for most wildlife species, development of toxicity reference values (TRVs) commonly relies upon toxicity data for laboratory test species. As a result, a number of regulatory agencies, including the U.S. EPA (U.S. EPA 2005) and United States Department of Energy (Sample et al. 1996) rely upon toxicological information for laboratory test animals for the development of their wildlife TRVs.

Allard et al. (2010) recommends that the uncertainty in extrapolation between species be minimized by selecting a test species that is as taxonomically or physiologically related to the wildlife species of interest as possible. On this basis, much of the toxicity data obtained from the medical and scientific literature relate to the exposure of laboratory test animals such as mice, rats, and guinea pigs, which were extrapolated to mammalian species, and poultry, which were extrapolated to avian species.

The lack of wildlife toxicity data presents three specific challenges:

- Health effects data gathered from the laboratory animals must be extrapolated to the wildlife species being assessed. This may require the use of ‘uncertainty’ factors to account for possible differences in physiology and uncertainty in sensitivity to the chemicals. The use of such uncertainty factors is a common practice in risk assessment. The exact extent to which uncertainty factors were applied was tempered by conventional thinking as to the level of protection required. Most authorities accept that for wildlife and other ‘ecological’ receptors, the primary concern relates to the health of the group (i.e., a population-based approach), whereas for humans, emphasis is placed on the person (i.e., an individual-based approach). Less protection is generally demanded in population-based health risk assessments, with less need for use of uncertainty factors.
- The study designs involved exposures of the laboratory test animals to a range of levels, often showing no effect at low exposure but adverse effects at higher exposures. The differences between the concentrations tested in the laboratory and those to which wildlife might be exposed must be considered to fully assess the significance of the information. Typically, the concentrations tested in the laboratory animals are considerably greater than those to which wildlife might be exposed in the environment.

- The bioaccessibility or bioavailability (i.e., chemical form) in which the compound is introduced to the test organism is designed to maximize uptake into the blood stream. Bioaccessibility is maximized in the laboratory setting to maximize toxic effects. The uptake of the highly bioaccessible form often results in very elevated exposures compared to uptake in the environment, where chemicals are often much less bioaccessible for a variety of physical and chemical reasons.

References:

Allard, P., A. Fairbrother, B.K. Hope, R.N. Hull, M.S. Johnson, L. Kapustka, G. Mann, B. McDonald and B.E. Sample. 2010. *Recommendations for the Development and Application of Wildlife Toxicity Reference Values*. Integrated Environmental Assessment and Management. 6(1):28-37.

http://www.epa.gov/ecotox/ecossl/pdf/ecossl_guidance_chapters.pdf

Hull, R.N. 2010. Personal communication with Ruth Hull via email on February 24, 2010 regarding Allard et al. (2010).

Sample, B.E., D.M. Opresko and G.W. Suter II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision*. Prepared by the Risk Assessment Program, Health Sciences Research Division. Prepared for the United States Department of Energy, Office of Environmental Management. June 1996.

U.S. EPA (United States Environmental Protection Agency). 2005. *Guidance for Developing Ecological Soil Screening Levels*. U.S. EPA, Office of Solid Waste and Emergency Response. November 2003, Revised February 2005.

http://www.epa.gov/ecotox/ecossl/pdf/ecossl_guidance_chapters.pdf

Request:

- ii. **Discuss how Shell considered the potential long-term residual effects on wildlife exposure to contaminants in process-affected wetlands and pit lakes when conducting the wildlife health assessment.**

Response:

- ii. In the Planned Development Case of the Wildlife Health Risk Assessment, it was assumed that wildlife would consume water and, when applicable, fish from the pit lake in the Far Future (i.e., 2065) with the highest incremental increase in chemical concentrations over the Base Case concentrations.

Request:

- iii. **Discuss the impacts of uncertainty and possible contamination of meat from wildlife health effects on traditional use and on the ACFN's Rights.**

Response:

- iii. Shell completed a Wildlife Health Risk Assessment, and included all relevant exposure pathways, including ingestion of water and vegetation. This assessment concluded that there would not be any likely significant adverse impacts to wildlife health. As indicated in Shell's EIA, pit lake water will not be released into receiving waterbodies and wetlands until it meets acceptable and safe AENV discharge criteria. Prior to that point, if pit lake waters are shown to be unacceptable to wildlife health, Shell will commit to mitigation measures such as taking steps to prevent wildlife from ingesting pit lake water (e.g., fencing) so as to minimize the risk of possible contamination of meat from this exposure pathway. Accordingly, Shell does not expect any significant adverse impacts to the exercise of ACFN's Aboriginal rights due to potential wildlife health impacts.

As part of the wildlife health risk assessment, wildlife tissue concentrations of the chemicals of potential concern (COPCs) were predicted for two distinct purposes:

- the prediction of potential health risks to wildlife, as a part of the Wildlife Health Risk Assessment (WHRA); and
- the prediction of potential health risks to people in the Human Health Risk Assessment (HHRA) as a result of wild game and fish tissue consumption.

In the prediction of wildlife tissue concentrations, all relevant exposure pathways, including inhalation of air and ingestion of water, soil, sediment, terrestrial and aquatic plants, and terrestrial and aquatic prey (i.e., invertebrates, fish and other prey), were considered. Although uncertainty can surround any risk assessment prediction, the uncertainty is accommodated, in part, through the use of assumptions which typically embrace a certain degree of conservatism and are often intentionally selected to represent reasonable 'worst-case' conditions.

The principal assumptions in the prediction of wildlife tissue concentrations include:

- Wildlife were assumed to be continuously exposed to the maximum predicted annual air concentrations of each of the COPCs within the health study area (including the JME and PRM "Maximum Points of Impingement" or MPOIs). It was assumed that wildlife would remain at this "maximum exposure" location (breathing the air and consuming all food and water from this location) for their entire lifetime. On this basis, wildlife would be exposed to the maximum predicted environmental media concentrations (i.e., air, water, soil, sediment, plants and prey) within the health study area for their entire lifetime. In the cases of water, sediment, aquatic plant and fish concentrations, this included the assumption that wildlife would drink water and ingest sediment, aquatic plants and fish from the pit lake with the highest predicted incremental increase over Base Case. Given the relatively large home ranges of many of the wildlife species (e.g., black bear, Canada lynx and moose), it is unlikely that wildlife

would remain at or in the vicinity of this maximum location over their entire lifetime. Thus, this assumption likely contributes to the exaggeration of the exposures that might be received by wildlife, and subsequently the wildlife tissue concentrations.

- Predicted environmental media concentrations (i.e., soil, plant and prey) were based on 75 years of continuous Project emissions and associated chemical deposition. The operating “life” of the Project is expected to be up to 40 years; thus, assuming 75 years of COPC emissions into the air as well as 75 years of deposition to environmental media likely contributes to the exaggeration of the exposures that might be received by wildlife, and subsequently the wildlife tissue concentrations.
- It was assumed that no degradation of the persistent or accumulative COPCs would occur in the environmental media (i.e., soil, plant and prey) over time (i.e., only continuous accumulation). Degradation of many of the persistent or accumulative COPCs will occur over time. As such, this assumption likely contributes to the exaggeration of the exposures that might be received by wildlife, and subsequently the wildlife tissue concentrations.

Due, in part, to the above assumptions and commitments made by Shell, the predicted wildlife tissue concentrations are unlikely to have been underestimated. Thus, it follows that the potential human and wildlife health risks, which incorporate these wildlife tissue concentrations, are also unlikely to have been underestimated. The overall conclusion of the HHRA and WHRA was that the potential human and wildlife health risks associated with the Project are considered low. Accordingly, Shell does not expect any significant adverse impacts to the exercise of ACFN’s Aboriginal rights due to the predicted wildlife tissue concentrations.

Request:

- iv. Given the significance of the wildlife to the ACFN’s traditional use and Aboriginal and Treaty rights, commit to provide the predictive results to the ACFN and to seek the ACFN’s verification of these predictions based on the TK of the ACFN.**

Response:

- iv. See response to questions 50 i, ii and iii. In the event that ACFN possess TK that would possibly impact the conclusions found in Shell’s Wildlife Health Impact Assessment, Shell requests that ACFN provide such information to Shell, along with an indication of how it might change Shell’s predictions, for Shell’s consideration.

59. Habitat modeling unclear.

Request:

Provide references (for response to SIR AENV 456c) and detailed descriptions of reclamation outcomes for re-evaluating wildlife habitat values on reclaimed lands.

Response:

The references cited in the response to AENV PRM Round 1 SIR 456c were:

- CEMA (2006, 2007),
- Golder (2007a,b) and
- WorleyParsons Komex (2007).

Detailed descriptions of reclamation outcomes were presented in the Closure and Reclamation Plan for the PRM (EIA, Volume 2, Section 20.3; Shell 2007) and JME (EIA Update, Appendix II, Section 2; Shell 2008) Project areas. Detailed descriptions of target ecosites phases and wetlands types discussed in the Closure Plan may be found in Beckingham and Archibald (1996).

The planting prescriptions are an assessment tool used to compare pre-development ecosites to post-reclamation plant communities. It is expected that that the reclaimed landscape will evolve and exhibit successional patterns similar to natural ecosite phases, depending on slope, aspect, moisture, and nutrient regimes. These reclamation projections are realistic based on current on-going research in the Oil Sands Region and are consistent with past and current revegetation guidelines provided by the Cumulative Environmental Management Association (OSVRC 1998; AENV 2010). These targets are widely accepted as an industry and regulatory standard to perform comprehensive assessments on terrestrial impacts of oil sands mining projects.

References:

AENV (Alberta Environment). 2010. *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2nd Edition*. Prepared by the Terrestrial Subgroup of the Reclamation Working Group of the Cumulative Environmental Management Association, Fort McMurray, AB. December 2009.

Beckingham, J.D. and J.H. Archibald. 1996. *Field Guide to Ecosites of Northern Alberta*. Natural Resources Canada, Northern Forestry Centre, Northwest Region. Special Report 5. Edmonton, AB.

CEMA (Cumulative Environmental Management Association). 2006. *Land Capability Classification System for Forest Ecosystems in the Oil Sands*. Fort McMurray, AB. Available online: http://cemaonline.ca/component/docman/doc_download/510-land-capability-classification-system-volume-1-field-manual-for-land-capability-determination.html

CEMA. 2007. *Guideline for wetland establishment on reclaimed oil sands leases (revised second edition)*. Prepared by M.L. Harris for CEMA Wetlands and Aquatics Subgroup of the Reclamation Working Group, Fort McMurray, AB. Dec/07. Available online: <http://www.assembly.ab.ca/lao/library/egovdocs/2008/aln/171465.pdf>

Golder (Golder Associates Ltd.). 2007a. *Surface Water Hydrology Environmental Setting for the Jackpine Mine Expansion and Pierre River Mine Project*. Prepared for Shell Canada Limited. Calgary, AB. Submitted December 2007.

Golder. 2007b. *Surface Water Quality Environmental Setting for the Jackpine Mine Expansion and Pierre River Mine Project*. Prepared for Shell Canada Limited. Calgary, AB. Submitted December 2007.

OSVRC (Oil Sands Vegetation Reclamation Committee). 1998. *Guidelines for Reclamation of Terrestrial Vegetation in the Oil Sands Region*. 48 pp + Appendices.

Shell (Shell Canada Limited). 2007. *Jackpine Mine Expansion & Pierre River Mine Project Application and Environmental Impact Assessment*. Volumes 1, 2, 3, 4 and 5. Submitted to Alberta Energy and Utilities Board and Alberta Environment, Calgary, Alberta. December 2007.

Shell. 2008. *Shell JME & PRM Project Environmental Impact Assessment Update*. Submitted to Alberta Environment. May 2008.

WorleyParsons Komex. 2007. *Jackpine Mine Expansion and Pierre River Mine Project – Base Case Report*. Prepared for Shell Canada Limited. Calgary, AB. Submitted December 2007.

60. Information on bison herd near project area insufficient.

Requests:

- i. Discuss how the proposed project may affect the Redclay Creek bison herd.**

Response:

The Project is predicted to have a negligible effect on abundance of bison within the Redclay Creed herd. Bison occurring on provincial lands outside of the

designated Hay-Zama management area are not protected by legislation unless they are owned as livestock. Bison in and around Wood Buffalo National Park are infected by the cattle diseases of bovine tuberculosis and bovine brucellosis (Mitchell and Gates 2002) and are typically hybrids of wood and plains bison. Hunting is not regulated around Wood Buffalo National Park to encourage harvest, and reduce the transmission of the diseases to the uninfected Hay-Zama pure wood bison herd within the special wildlife management area as well as to agricultural livestock on grazing leases further south. The Project LSAs fall within the zone where the Province is trying to restrict bison populations and therefore the Pierre River project is consistent with the Provincial Management Plan and has no additional impact.

References

- Mitchell, J.A. and C.C. Gates. 2002. Status of the wood bison (*Bison bison athabascae*) in Alberta. Alberta Wildlife status Report No. 38. Alberta Sustainable Resource Development and Alberta Conservation Association, Edmonton, Alberta. 42 pp.
- Shell (Shell Canada Energy). 2007. *Application for the Approval of the Jackpine Mine Expansion and Pierre River Mine Project*. Wildlife and Wildlife Habitat Environmental Setting Report. Submitted to Alberta Energy Resources Conservation Board and Alberta Environment. December 2007.

Species At Risk Public Registry. 2010. <http://www.sararegistry.gc.ca>. Accessed March 18, 2010.

Requests:

- ii. **Given the significance of the wildlife to the ACFN's traditional use and Treaty and Aboriginal rights, commit to provide the predictive results to the ACFN and to seek the ACFN's verification of these predictions based on the TK of the ACFN.**

See part i of the response to question 60.

61. Cumulative effects of tailings ponds on migratory bird populations not assessed.

Request:

- i. **Provide the results of a comprehensive assessment of the cumulative effects of oil sands tailings ponds on migratory bird populations and health-based on a pre-industrial baseline.**

Response:

- i. Refer to Section 1.0 of the JME Technical Review response document for an explanation as to why a pre-industrial baseline assessment was not included in the EIA.

A comprehensive assessment of the cumulative effects of interactions with oil sands tailings ponds and other Project infrastructure on the abundance of migratory birds are assessed in the EIA using yellow rail and black-throated green warbler as KIRs. Environmental consequences were predicted to be low at the local scale, and negligible at the regional scale after mitigation (Volume 5, Section 7.5.3.2; Shell 2007). The effects of the Project were predicted relative to a Base Case that includes consideration of the existing environmental conditions as well as existing and approved projects or activities within the study area (EIA, Volume 3, Section 1.3.3). A Base Case that includes existing and approved developments is consistent with the most recent Guide to Preparing Environmental Impact Assessment Reports in Alberta (Government of Alberta 2010). Assessment scenarios that occur far back in time result in great uncertainty in predictions, and would not result in an accurate cumulative effects assessment (CEAWG and AXYS 1999).

The potential risks posed to waterfowl were assessed in the wildlife health risk assessment (WHRA, see Section 5.4, Volume 3 of the EIA). The WHRA characterized risks for the mallard and great blue heron by considering the potential changes in air quality, water quality, soil quality and food quality (i.e., dietary items such as benthic invertebrates, aquatic and terrestrial plants for mallards and fish for great blue heron). The uptake of persistent and bioaccumulative chemicals by waterfowl was then carried forward to the human health risk assessment, wherein people (including those residing in the Peace-Athabasca Delta) were assumed to eat the potentially-affected waterfowl (i.e., mallard).

Risks to waterfowl associated with changes to the water quality were based solely on impacts related to process-affected waters and did not consider the direct exposure of waterfowl to the external tailings disposal areas. As described in the EIA, effects resulting from waterfowl interactions with tailings ponds will be reduced through the implementation of a bird deterrent system that will employ radar-activated scare cannons (see Section 7.5.3.2, Volume 5 of the EIA). As such, direct exposure to the tailings ponds was not assessed in the WHRA.

For a discussion of potential risks posed to migratory birds, please see the response to question 44.

References:

CEAWG (Cumulative Effects Assessment Working Group) and AXYS (AXYS Environmental Consulting Ltd.). 2010. *Cumulative effects assessment practitioners guide*. Prepared for

the Canadian Environmental Assessment Agency. 134 pp. Available online: http://www.ceaa.gc.ca/43952694-0363-4B1E-B2B3-47365FAF1ED7/Cumulative_Effects_Assessment_Practitioners_Guide.pdf

Government of Alberta. 2010. *Guide to preparing environmental impact assessment reports in Alberta*. Environmental Assessment Program. 35 pp. Available online: <http://environment.alberta.ca/01499.html>

Shell (Shell Canada Limited). 2007. *Jackpine Mine Expansion & Pierre River Mine Project Application and Environmental Impact Assessment*. Volumes 1, 2, 3, 4 and 5. Submitted to Alberta Energy and Utilities Board and Alberta Environment, Calgary, Alberta. December 2007.

Request:

- ii. **Discuss the effects of these changes on traditional use and on the ACFN's Rights.**

Response:

- ii. The details and effectiveness of Shell's migratory Bird Deterrent System is contained in Vol. 5, Section 7.3 of the EIA. Shell tracks and reports bird and other wildlife fatalities to the appropriate regulatory agencies on an annual basis. For Jackpine Mine in 2010, there were approximately 11 ETDA-related migratory bird mortalities, and at Muskeg River Mine, there were approximately 6 ETDA – related migratory bird mortalities. Given the size of regional migratory bird populations, there is no effect on traditional use or the exercise of ACFN's rights insofar as those uses and rights are dependent on migratory bird populations.

Request:

- iii. **Commit to provide these findings to the regulators as a key input to the public interest determination.**

Response:

- iii. Shell completed its EIA in accordance with the Terms of Reference prescribed by Alberta Environment, consistent with the *Guide to Preparing Environmental Impact Assessment Reports in Alberta* (Government of Alberta, 2010, as amended). A Deemed Complete decision was announced by AENV in October 2010. Accordingly, there are no plans to reassess cumulative effects of oil sands tailings ponds on migratory bird populations and health utilizing a pre-industrial baseline.

62. Cumulative effect of multiple projects on wildlife inadequately assessed.

Request:

- i. **Provide estimates of wildlife populations, habitat availability, and vegetation communities (including wetlands) under pre-industrial conditions, and compare these to the present day and 'Base Case' scenarios.**

Response:

- i. See Section 1.0 of the JME Technical Review response document for an explanation for why a pre-disturbance baseline was not used in the assessment.

References:

CEAWG (Cumulative Effects Assessment Working Group) and AXYS Environmental Consulting Ltd. 2010. *Cumulative effects assessment practitioners guide*. Prepared for the Canadian Environmental Assessment Agency. 134 pp. Available online: http://www.ceaa.gc.ca/43952694-0363-4B1E-B2B3-47365FAF1ED7/Cumulative_Effects_Assessment_Practitioners_Guide.pdf

Government of Alberta. 2010. *Guide to preparing environmental impact assessment reports in Alberta*. Environmental Assessment Program. 35 pp. Available online: <http://environment.alberta.ca/01499.html>

Request:

- ii. **Identify the expected area of land from which wildlife and vegetation would migrate back into the reclaimed land, taking into consideration any nearby operations which would be also be cleared.**

Response:

- ii. As discussed in the response to request 53i, cumulative effects of multiple projects on wildlife were adequately assessed, and followed the approach recommended in the most recent *Guide to Preparing Environmental Impact Assessment Reports in Alberta* (Government of Alberta 2010, as amended).

Wildlife recolonization and movement of vegetation seed will occur from sources in relatively undisturbed habitats to the east of the JME LSA along the retained movement corridors shown in Figure 49-1. Recolonization of the disturbed landscape by wildlife will occur in a predictable progression following reclamation of the landscape.

Species will take advantage of the reclamation areas at various plant community development stages when life requisites are met within or adjacent to the reclaimed sites. Small mammals, including microtines (small rodents) and snowshoe hares are often the first wildlife to occupy newly reclaimed areas (Fort McKay 1997). These species create a prey base that provides the essential food requirements allowing

colonization by raptors and small to mid-sized carnivores such as weasels. The small mesocarnivores such as weasels will exploit the small mammal prey base when cover areas on the reclaimed site provide the security and stalking cover preferred by these species.

Invasive and opportunistic species that are more tolerant of humans, such as deer, fox and coyote, are expected to be some of the first of the larger wildlife species on the reclaimed site. Other tolerant species, including many bird species, will also make use of the reclaimed site early in its development. Over time, as vegetation matures to provide adequate food (browse), moose, the largest ungulate, will begin using the reclaimed area. Finally, the more elusive, wide-ranging wildlife species (e.g., wolf) and species requiring mature and old growth forests (e.g., marten, fisher and lynx) will colonize the area.

Suncor Energy Inc. (Suncor) has completed assessments of wildlife use of reclaimed areas on Lease 86/17. Results of these assessments show that several reclamation areas are providing permanent or temporary habitat for some key wildlife indicator species (Golder 2004). Efforts to evaluate wildlife use of reclamation will continue as currently reclaimed areas on oil sands project areas mature.

References:

Golder (Golder Associates Ltd.). 2004. *Suncor Energy Wildlife Monitoring Program and Wildlife Assessment Update: Years 1999 to 2003*. Prepared for Suncor Energy Inc. Fort McMurray, AB. 23 pp + Appendices.

Government of Alberta. 2010. *Guide to preparing environmental impact assessment reports in Alberta*. Environmental Assessment Program. 35 pp. Available online: <http://environment.alberta.ca/01499.html>

Fort McKay (Fort McKay Environmental Services Limited). 1997. *Summer Field Reconnaissance to Determine the General Composition of Flora and Faunal Groups Present in the Former Alsands Lease and Their Relation to Traditional Resources Used by the Members of the Community of Fort McKay*. Prepared for Shell Canada Limited. Fort McKay, AB. 27 pp.

Request:

- iii. **Discuss and assess the impacts of the changes in wildlife in the region on traditional use and on the Rights of the ACFN.**

Response:

- iii. Shell's EIA has assessed the predicted impacts on a cumulative effects basis, and has incorporated the impact of existing, approved and planned projects, as well as more contemporary monitoring data.

Accordingly, Shell submits that ACFN have cumulative impact information regarding "changes in wildlife", and based on available information surrounding the extent of ACFN's self-identified traditional land use areas, and Shell's proposed mitigation measures (including closure and reclamation plans), Shell predicts no significant impacts on the wildlife resources used by the ACFN for their traditional use or exercise of rights related to wildlife use.

Request:

- iv. Given the significance of the wildlife to the ACFN's traditional use and Treaty and Aboriginal rights, commit to provide the predictive results to the ACFN and to seek the ACFN's verification of these predictions based on the TK of the ACFN.**

Response:

- iv. As discussed in the response to request 53i, cumulative effects of multiple projects on wildlife were adequately assessed, and followed the approach recommended in the most recent *Guide to Preparing Environmental Impact Assessment Reports in Alberta* (Government of Alberta 2010). Predicted changes to wildlife habitat from Base Case through Application Case to Closure are provided in Appendix V of the EIA Update for the JME (Shell 2008), and in Appendix 5-4 of the EIA for the PRM (Shell 2007). Predicted environmental consequences of the effect of the JME and PRM on wildlife and vegetation are provided in Volume 5 of the EIA.

References:

Government of Alberta. 2010. *Guide to Preparing Environmental Impact Assessment Reports in Alberta*. Environmental Assessment Program. 35 pp. Available online: <http://environment.alberta.ca/01499.html>

Shell (Shell Canada Limited). 2007. *Jackpine Mine Expansion & Pierre River Mine Project Application and Environmental Impact Assessment*. Volumes 1, 2, 3, 4 and 5. Submitted to Alberta Energy and Utilities Board and Alberta Environment, Calgary, Alberta. December 2007.

Shell. 2008. *Shell JME & PRM Project Environmental Impact Assessment Update*. Submitted to Alberta Environment. May 2008.

1.8 Vegetation, Wetlands, and Biodiversity

63. KIR frequency ratings between LSA and RSA differ.

Request:

Assuming that each piece of land will be cleared once, explain the relevancy of rating the frequency of clearing for different events, in different locations.

Response:

The difference in frequency rating referred to above is due to the difference between the Application Case and PDC, and is not the result of scale issues between the LSA versus the RSA. The difference in frequency rating is due to timing or rate of clearing in each case. In the Application Case, the only source of change to the environment is a single development (the Project) that will be cleared, and it is assumed that the entire area is cleared at once. Thus, the frequency rating is low for both the LSA and RSA at the Application Case. For the PDC, each planned or approved project is assumed to be 100% cleared as an individual event, thus the clearing of all developments are considered to be different events on the specific resource in the PDC. Therefore, a frequency rating of high is assumed for the PDC.

64. Regional vegetation data lacking.

Request:

- i. Discuss how the lack of refined scale maps (i.e., lack of current and accurate regional vegetation data) affects the impact assessment for this project.**

Response:

- i. The vegetation assessment for the RSA is based on a regional land cover classification developed by Golder. When the RSA assessment was completed the most current mapping imagery was used (i.e., Landsat 5 and 7) to ensure as accurate a classification as possible. Upon completion of the RSA map, the accuracy of the map was tested by comparing classified categories to ground-truthed sites. This is an accepted approach with regulators for conducting vegetation assessments, and has precedence in other EIAs that have gone through the regulatory process.**

An overall accuracy assessment of the Landsat imagery classification in the RSA was identified as 80% in June 2006. Classified land cover classes were compared to about 176 ground-truthed sites, to verify and train satellite imagery. Where necessary, land

cover classes that were not true to identified classes were reclassified based on additional information.

Although difficulties in identifying land cover classes are inherent during classification, the classification and accuracy assessment methods used to develop the RSA map are considered an accurate representation of the RSA.

Request:

- ii. Discuss Shell's commitment to fill this gap.**

Response:

- ii. Shell is not planning to undertake any additional work within the RSA as a part of this Project as the regional vegetation data are robust, and Shell does not believe that a gap exists in the current data (see response to question 55i). However, Shell participates in CEMA and Petroleum Technology Alliance Canada (PTAC), both associations that have partnered with various other stakeholders to undertake ecological research in the Oil Sands Region. Where appropriate and applicable, the results of this research may be applied to improve current practices and data as well as to advance ecological knowledge in the region.

Request:

- iii. Commit to standardize and share vegetation data sets (e.g., through CEMA's database) with other operators and government agencies.**

Response:

- iii. Shell is open to discussing the appropriateness of sharing vegetation datasets with other stakeholders as is appropriate.

65. Groundwater-dependent traditional plants may be impacted.

Request:

Explain in detail, using an appropriate set of time sequences, how the loss of groundwater-dependent traditional plant areas in the active mining area and in the surrounding area would be mitigated, offset, or compensated.

Response:

The primary mitigation for the effects of the Project on vegetation is reclamation. After closure and reclamation, conditions conducive to the reestablishment of groundwater-

dependent traditional plant species are expected to occur. Shell is not planning on mitigating or providing offsets for impacts to ground-water dependent traditional plants or compensating for the loss of these species within the Project areas.

66. Loss of old growth forests inadequately assessed.

Request:

- i. **Explain why “Magnitude of Impact” in the local study area for loss of old growth forest is not ranked as high (>20%), and therefore the environmental consequence also not ranked as high (+17) in Table 7.5-34 (EIA Section 7.5). Explain why using a 2% loss of the local study area is more biologically relevant than using a 40% loss of the actual feature being assessed.**

Response:

- i. The effects of the loss of old growth forest have been assessed based on the percent of the LSA, and this approach remains one measure of the loss of old growth within the LSA. It is recognized that the amount of the resource lost relative to the total amount of that resource in the LSA provides an alternative measure of the effects of the project on old growth as was reported in the Terrestrial Vegetation, Wetlands and Forest Resources impact assessment in Volume 5 of the EIA.

Request:

- ii. **Repeat the assessment using the ‘high’ ranking, as noted above.**

Response:

- ii. It is recognized that the effects of the loss of old growth forest could be assessed based on the percent of the resource. If the loss of old growth was presented as a percent of the resource, a high magnitude impact would be attributed to old growth forest loss (40%) for the LSA. Consequently, the magnitude would be considered high (score of +15), resulting in an environmental consequence score of +17, and therefore a moderate environmental consequence to old growth forests in the LSA. This moderate environmental consequence would not be considered a likely significant adverse environmental effect as the effect on old growth forest in the RSA is negligible.
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67. Project-related and regional loss of wetlands inadequately assessed.

Request:

- i. **Explain the lack of compensation for the irreversible loss of a significant area of wetlands in the PRM project area.**

Response:

- i. The low environmental consequence to wetlands as a result of existing approved and planned developments in the RSA demonstrate that wetlands will remain a large proportion on the RSA landscape, including after mine reclamation (refer to EIA, Section 7.6.2.1, Table 7.6-6). Because of the large area of wetlands that will remain in the RSA and the majority of wetlands in the LSA are peatlands, which presently cannot be reclaimed, Shell does not propose compensation for wetlands lost in the Project area.

References:

- Forsyth, A. 1985. *Mammals of the Canadian Wild*. Camden House. Camden East, ON. 351 pp.
- Semenchuk, G.P. 1992. *The Atlas of Breeding Birds of Alberta*. Federation of Alberta Naturalists. Edmonton, AB. 393 pp.

Request:

- ii. **Discuss and assess the cumulative impacts arising from the PRM's predicted permanent wetland loss, as well as the total loss of wetlands in the entire Oil Sands Region on biodiversity, habitat loss, wildlife, traditional users, groundwater, surface water, and vegetation. Use a pre-industrial baseline for all assessments.**

Response:

- ii. Refer to Section 1.0 of the JME Technical Review response document for an explanation as to why a pre-industrial baseline assessment was not included in the EIA.

An assessment of cumulative impacts to wetlands in the RSA as a result of the Project and other planned developments in the region is provided in the EIA, Volume 5, Section 7.5.2.2, Table 7.5-14. Potential cumulative impacts to wildlife and wildlife habitat and biodiversity are discussed in EIA, Volume 5, Sections 7.6.3 and 7.6.4, respectively. Potential cumulative impacts to groundwater and surface water due to wetland loss are not assessed directly; however, predicted cumulative effects are discussed in the EIA Volume 4, Sections 6.3.8 and 6.4.8, respectively. Cumulative impacts from the loss of wetlands to traditional users is addressed in the response to question 67iv.

Request:

- iii. **Identify what biodiversity offsets Shell would plan or be willing to commit to as a means of lessening the consequences of the inevitable loss of natural biodiversity**

from the PRM Project or for the losses from regional oil sands industrial activities.

Response:

- iii. Shell is not proposing any biodiversity offsets as part of its project commitments. Local loss of high biodiversity potential has been anticipated in the EIA, mostly due to loss of peatlands, and Shell is continuing research on developing peatlands in reclaimed landscapes.

Shell understands the concerns of ACFN and has designed for areas of gently sloping topography on the closure landscape. These areas have the potential to create the hydrological conditions suited to peatland formation. For Jackpine Mine Expansion, Shell is planning for approximately 65% of the closure landscape (13,360 ha) to have slopes between 0 and 2%. For Pierre River Mine, Shell is planning for approximately 52% of the closure landscape (5,430 ha) to have slopes between 0 and 2%.

Shell also supports including peatland re-establishment trials within operational closure and reclamation plans. Shell is engaged in supporting the CONRAD peatland reclamation research, and will be applying this information to reclamation on Shell sites. Shell also participates in the work of the CEMA RWG.

Request:

- iv. **Discuss the impact of the loss of wetlands on traditional use and on the Rights of the ACFN.**

Response:

- iv. Shell's EIA predicts that planned developments will result in less than 1% of all wetlands in the regional study area. This is classified as a low environmental consequence, and is not considered significant. Also, a review of available ACFN TLU mapping information, which shows the "core" areas of ACFN's TLU area, as well as the 2003 ACFN TLU study, both of which were filed in the Total Joslyn North Mine Joint Review Panel (JRP) public hearing, show that the vast majority of ACFN traditional use areas (including game and fowl hunting, berry and medicine hunting, and traditional and spiritual sites) occur in the vicinity of Fort Chipewyan and the Richardson Backcountry. The 2008 TLU information from ACFN, based on interviews with participants chosen based on proximity to the Shell leases does disclose some traditional use areas in and around Kears Lake (some of which are based on access to wetlands), but when combined with the information outlining the rest of ACFN's traditional use areas, combined with the above-noted low impact to wetlands in the RSA after reclamation and mitigation, no significant impacts to the overall exercise of ACFN's traditional activities are expected.

68. Wetland ecological equivalency assumption unsupported.

Request:

Provide research supporting the assumption that reclaimed non-treed wetlands are ecologically equivalent to peatlands, or revise the assessment to reflect the true significance of the full loss of the wetlands in this project area.

Response:

The EIA does not assume that all reclaimed non-treed wetlands in the RSA will be ecologically equivalent to pre-disturbance peatland types. In instances where a cumulative impact to a treed fen or treed bog/poor fen land cover class is the result of seismic lines, cutlines or other linear disturbances, it is assumed that at closure regeneration will not result in a return to a treed fen or treed bog/poor fen land cover class over the 80 year time frame of the assessment. However, since the underlying soils (peat or mineral) are not removed, they will remain a peatland or mineral wetland and can be considered equivalent to the pre-disturbance land cover class type.

In instances where peat is permanently removed or altered, it is assumed that these peatlands cannot be reclaimed. Any non-treed wetlands that replace any of these disturbed peatlands are also not assumed to be ecologically equivalent in the assessment, although over time they may provide certain functions (e.g., surface water conveyance, habitat for some wildlife species) similar to pre-disturbance peatland types.

69. Additional information for weeds and non-native invasive species required.

Request:

Request:

- i. Explain how Shell would control the introduction and spread of invasive nonnative species during construction and reclamation.**

Response:

- i. During construction, Shell intends to follow the same weed management plan as is currently in place at the Muskeg River Mine and Jackpine Mine – Phase 1 sites, where only clean equipment is allowed access for delivery and use on the sites (also refer to PRM Round 1 AENV SIRs 350, 381, 511). Contractors or personnel with vehicles new

to the site must ensure that the vehicles are clean before entry (see PRM Round 1 AENV SIR 381).

During reclamation, Shell will ensure that native vegetation will be established on reclaimed sites by expanding and implementing the existing weed control system used at its current oil sands operation in the proposed project area (see EIA, Volume 5, Section 7.1). The vegetation reclamation monitoring program will be designed to evaluate the success of reclamation procedures over time to mitigate the encroachment of invasive plant species and promote the establishment of woody stemmed species (see the EIA, Volume 5, Appendix 5-6). Shell will manage invasive weeds as required by the *Alberta Weed Control Act* (Province of Alberta 2010).

Revegetation will be conducted according to appropriate guidelines for vegetation re-establishment in the Oil Sands Region. Current guidelines (AENV 2010) outline that the planting prescriptions for reclaimed sites must be comprised of native vegetation types. The recommended planting prescriptions, in addition to regular weed monitoring programs, are designed to reduce the potential for over-competition by invasive plant species (see PRM Round 1 SIR 350b).

References:

AENV (Alberta Environment). 2010. *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2nd Edition*. Prepared by the Terrestrial Subgroup of the Reclamation Working Group of the Cumulative Environmental Management Association, Fort McMurray, AB. December 2009.

Province of Alberta. 2010. *Weed Control Act and Weed Control Regulation 19/2010*. Alberta Queen's Printer. Edmonton, AB.

Request:

- ii. **Clarify whether the access to the construction site and subsequent plant site will be fully paved, or if not, how contractors would ensure that their vehicles are clean upon entering the site.**

Response:

- ii. It is not Shell's intention to have a plant site that is fully paved. During construction, Shell intends to follow the same weed management plan as is currently in place at the Muskeg River Mine and Jackpine Mine – Phase 1 sites, where only clean equipment is allowed access for delivery and use on the sites. Contractors or personnel with vehicles new to the site must ensure that the vehicles are clean before entry (see PRM Round 1 AENV SIR 381a).

70. Impacts to traditionally-used plants not adequately assessed.

Request:

- i. Describe which plant species are considered important by the Aboriginal communities, and assess the impacts on those species.**

Response:

- i. Table 8.3-1 summarises plant and animal species identified by First Nations as having traditional use value within the RSA (refer to the Traditional Land Use Assessment in the EIA, Volume 5, Section 8.3.3.3, Table 8.3-1). Based on the list of plant species provided in Table 8.3-1 and other known traditional use plant species in the region, approximately 102 different species of traditional use plants were identified in the LSA during field surveys. Of these species, the vast majority are common throughout the LSA and can be expected to be common throughout the RSA (e.g., green alder, stiff club moss and common yarrow). Based on field data, only a few of these species had low occurrences in the LSA (e.g., sweet grass, wild mint, fern species, beaked hazel nut, dragonhead), although all these species are known to occur throughout the province (NatureServe 2010). None of the traditional use species recorded in the LSA is tracked by the Alberta Conservation Information Management System (ACIMS).

Potential impacts on individual species listed in Table 8.3-1 are not directly assessed in the EIA. However, a traditional plant potential (TPP) ranking, derived from detailed vegetation data collected in the Oil Sands Region, is used to predict effects. In the EIA, Volume 5, Section 7.5.2.2, Tables 7.5-31 and 7.5-32, impacts to traditional plants in the LSA and RSA are assessed respectively. Effects from the project on TPP result in a negligible environmental consequence in the LSA and a negligible consequence in the RSA (refer to the EIA, Volume 5, Section 7.5.2.2, Table 7.5-34).

Rankings (i.e., high, medium and low) in the Traditional Land Use ESR were given to individual species based on the number of times that species was referred to and the number of times it was shown on the traditional land use maps or in tables that accompany the studies (Traditional Land Use ESR, Table 3.3-1). These rankings provide an indication of the extent of their harvest and use and are not meant to be a reflection of the importance of specific resources or to imply that certain species are unimportant.

References:

NatureServe. 2010. *NatureServe Explorer: An online encyclopedia of life [web application]*. Version 7.1. NatureServe, Arlington, Virginia. Available <http://www.natureserve.org/explorer>. Accessed: March 18, 2010.

Request:

- ii. **Identify thresholds/criteria used by Shell to assess potential impacts on traditional users from loss of traditionally-used plants.**

Response:

- ii. The Terms of Reference for the Terrestrial Vegetation, Wetlands and Forest Resources component are focused on ecological criteria. Accordingly, the information acquired through field work was used to analyse and assess various KIRs and other criteria based on potential affects to ecological variables (e.g., vegetation communities, rare plants). However, a TPP assessment, based on field data from the Oil Sands Region, was completed to predict effects to vegetation communities with a high, moderate or low traditional use plant potential (refer to the EIA, Volume 5, Section 7.5.2.2, Tables 7.5-31 and 7.5-32). Additional discussion of potential affects to traditional use plants is located in the Traditional Land Use Assessment (refer to the EIA, Volume 5, Section 8.3.3.3).

71. Rare plants assumption unsupported.

Request:

Provide scientific evidence, using multiple species of rare plants with different habitat requirements and rarity classes, that rare plants would move into reclaimed habitats in the Oil Sands Region.

Response:

Shell is confident that the revegetation strategy will provide the conditions needed for the natural reestablishment of biodiversity levels consistent with pre-development conditions. The reclaimed landscape is predicted to provide the potential for the natural re-colonization of rare plants. Direct placement of reclamation materials will be undertaken whenever practical to maximize potential viability of native seed banks and propagules, which has the potential to include rare plants. Natural invasion of native vegetation (including rare plants) will be encouraged in ecologically-receptive areas. Reclamation monitoring efforts will identify plant species that do not ingress naturally and they will be planted or seeded where required to meet reclamation certification criteria. Appropriate species are expected to thrive once suitable conditions have been established.

The most advanced information is available from reclaimed sites in Europe, such as reclamation of the Szczakowa Sand Pit mine in Poland (Pietrzykowski 2008) which noted that rare plants had been located after natural ingress into diverse microsites in reclaimed areas. The successful restoration of a river valley in Denmark provides another example of the natural ingress of two rare aquatic plant species in a reclaimed riverine landscape (Pedersen et al. 2007). Shell is committed to participating in reclamation research in the Oil Sands Region and will implement appropriate reclamation strategies as they relate to rare plants, as information becomes available.

References:

Pedersen, M.L., J.M. Andersen, K. Nielsen and M. Linnemann. 2007. *Restoration of the Skjern River and its valley: project description and general ecological changes in the project area*. Ecological Engineering 30:131-144.

Pietrzykowski, M. 2008. *Soil and plant communities development and ecological effectiveness of reclamation on a sand mine cast*. Journal of Forest Science 54:554-565

72. Evaluation of Rare Plant Potential inadequate.

Request:

Evaluate the impacts on actual rare plant occurrences using Alberta Natural Heritage Information Centre (ANHIC) records (Government of Alberta 2009).

Response:

Table 72-1 summarizes rare plant occurrences identified in the PRM LSA and known occurrences in the RSA. This information is based on field data collected in the LSA and acquired from ACIMS (2010). Data summaries include historical occurrences acquired from ACIMS and survey data collected in the PRM LSA. The project will affect 44 different rare plant species resulting in the loss of 201 occurrences of vascular and non-vascular tracked species in the PRM LSA.

Results from ACIMS (2010) and NatureServe (2010) indicate that species affected by the project are either known to have additional occurrences in the RSA or that their known distributions occur in other provinces in Canada. Only *Rinodina anomala*, *Rinodina capensis* and *Usnea angulata*, are known to occur only in the PRM LSA, but are known from outside of the province (refer to PRM Round 1 AENV SIR 472 for additional information). However, lichens as a group are

under-collected, and the lichen flora of Alberta is poorly known, especially in the northern and eastern portions of the province (Goward 2007, pers. comm.). For example, crustose lichens, in particular, are less likely to be collected during baseline data collection field surveys because they are closely attached to their substratum and difficult to remove. Since many species of lichen are known to cover a broad range of habitat types and substrates, it is probable that the listed lichen species identified in the PRM LSA are also found in other areas of the LSA and the RSA.

Table 72-1 Number of Vascular and Non-Vascular Species Occurrences in the Local Study Area and Known in the Regional Study Area

Scientific Name	Common Name	Rare Plant Occurrences lost in the PRM LSA	Known Rare Plant Occurrences in the RSA
<i>Anastrophyllum helleranum</i>	liverwort	1	20
<i>Arthonia patellulata</i>	no common name	8	20
<i>Bryoria simplicior</i>	old man's beard	2	10
<i>Calypogeia muelleriana</i>	no common name	1	1
<i>Candelariella lutella</i>	no common name	2	4
<i>Cephaloziella rubella</i>	no common name	1	1
<i>Cladina stygia</i>	no common name	1	1
<i>Cladonia ochrochlora</i>	no common name	1	1
<i>Cliostomum pallens</i>	no common name	4	16
<i>Coptis trifolia</i>	no common name	2	2
<i>Cyphelium tigillare</i>	soot lichen	1	2
<i>Cypripedium acaule</i>	stemless lady's-slipper	2	27
<i>Imshaugia placorodia</i>	American starburst lichen	10	30
<i>Lecanora hybocarpa</i>	no common name	2	2
<i>Lecanora hypoptoides</i>	no common name	3	3
<i>Lecanora laxa</i>	no common name	1	5
<i>Lecanora persimilis</i>	no common name	5	16
<i>Lecanora subintricata</i>	no common name	17	38
<i>Lecidea leprarioides</i>	no common name	1	4
<i>Lecidea nylanderii</i>	no common name	9	14
<i>Lecidea porphyrospoda</i>	no common name	1	13
<i>Lecidella elaeochroma</i>	no common name	6	18
<i>Leucophysalis grandiflora</i>	no common name	3	3
<i>Melanelia trabeculata</i>	no common name	7	13
<i>Micarea prasina</i>	no common name	1	1
<i>Micarea sylvicola</i>	no common name	5	8
<i>Nephroma bellum</i>	no common name	1	1
<i>Phaeocalicium compressulum</i>	no common name	4	4

Scientific Name	Common Name	Rare Plant Occurrences lost in the PRM LSA	Known Rare Plant Occurrences in the RSA
<i>Phlyctis argena</i>	no common name	1	1
<i>Plagiochila porelloides</i>	no common name	2	4
<i>Ramalina dilacerata</i>	punctured ramalina	29	49
<i>Ramalina obtusata</i>	no common name	1	1
<i>Rinodina anomala</i>	no common name	1	1
<i>Rinodina capensis</i>	no common name	1	1
<i>Rinodina disjuncta</i>	no common name	5	6
<i>Rinodina metaboliza</i>	no common name	4	8
<i>Rinodina orculata</i>	no common name	3	4
<i>Scoliciosporum perpusillum</i>	no common name	38	116
<i>Scoliciosporum umbrinum</i>	no common name	1	3
<i>Stenocybe pullatula</i>	alder stickpin	3	5
<i>Trapeliopsis flexuosa</i>	no common name	1	1
<i>Tuckermannopsis orbata</i>	variable wrinkle-lichen	6	11
<i>Usnea angulata</i>	no common name	1	1
<i>Usnea scabiosa</i>	no common name	2	17
Total		201	507

References:

ACIMS (Alberta Conservation Information Management System). 2010. ANHIC Data Request. Parks Division, Alberta Tourism, Parks and Recreation. Available at: <http://tpr.alberta.ca/parks/heritageinfocentre/datarequests/default.aspx>
Accessed: March 18, 2010.

NatureServe. 2010. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available <http://www.natureserve.org/explorer>. Accessed: March 18, 2010.

Personal Communications:

Goward, T. 2007. Enlivened Consulting Ltd. Personal Communication with Darrin Nielsen, Golder Associates Ltd. E-mail correspondence. January 11, 2007.

73. Rare plant surveyors not identified.

Request:

Identify the botanists used for the rare plant surveys in the assessment, as well as their qualifications. Clarify whether these botanists were on all the detailed inventory surveys as well as the rare plant surveys.

Response:

The terrestrial ecologists listed below were used to complete field work for either the JME and/or PRM assessments:

- Austin Adams, B.Sc. – Terrestrial Ecologist, Detailed vegetation inventories and rare plant surveys
- Jason Kamin – Terrestrial Ecologist, Detailed vegetation inventories and rare plant surveys
- Pat Marlowe, B.Sc, M.Sc. – Terrestrial Ecologist, Detailed vegetation inventories and Rare Plant Surveys, sedge specialist
- Chad Willms, B.Sc., M.Sc. – Terrestrial Ecologist, Detailed vegetation inventories and rare plant surveys
- Darrin Nielsen, B.Sc. – Senior Terrestrial Ecologist, Detailed vegetation inventories and rare plant surveys

The following ecologists were used to identify vascular plant, moss, liverwort or lichen specimens:

- Cynthia Lane, PhD – Senior Terrestrial Ecologist, vascular plant species identification.
 - Trevor Goward, M.Sc. – lichenologist.
 - Curtis Bjork, M.Sc. – lichenologist.
 - Dale Vitt, PhD – bryologist.
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74. Additional details about the accuracy of vegetation maps required.

Request:

Identify whether the accuracy of RSA vegetation maps was determined by ground data or from air photo interpretation.

Response:

Landsat 5 and 7 Thematic Mapper images were used to map regional vegetation with an approximate pixel size of 30 x 30 m on the ground. Classification accuracy was performed using ground-truthed testing sites and an error matrix was produced.

An accuracy assessment was completed for the RSA classification. The classified Landsat dataset was queried to randomly select 10 polygons for each land cover class. The 10 largest polygons for each class that did not overlap the training areas were used for the classification and did not overlap disturbance areas. Classified regional land cover classes were compared to about 176 ground-truthed sites, to verify the Landsat imagery. An overall accuracy assessment of the Landsat imagery classification in the RSA was identified as 80% in June 2006.

75. Impacts of combined air emissions on vegetation key indicator resources unclear.

Request:

Provide a qualitative description of how air emissions (PAI, SO₂, NO₂, and eutrophication) might cumulatively affect plants around the mine during operations and reclamation, taking synergistic effects into consideration.

Response:

Potential effects of air emissions considered in this assessment include acid deposition resulting from emissions of oxides of nitrogen (NO_x) and SO₂ as well as direct effects of ground-level concentrations of SO₂, NO₂ and ozone (O₃) on vegetation. To account for indirect effects on vegetation a Terrestrial Resources Air Emissions Effects Study Area (TASA) was established that includes terrestrial vegetation and wetlands within and beyond the LSAs. The TASA was created using the furthest measurable extent of predicted potential impact for PAI, NO₂ and SO₂ emissions.

The terrestrial air emissions effects assessment is based on "soil net PAI", which takes into account uptake of N in terrestrial ecosystems (wetlands are combined with terrestrial systems in this assessment). Acidic deposition for terrestrial resources is evaluated through comparison of soil net PAI to soil-series-specific critical loads. As most of the effects are related to chronic exposure, the annual average values for air emissions are considered for soil net PAI. The calculation of soil net PAI includes all SO₂ deposition, all NO_x deposition above 10 kg N/ha/yr and 25% of NO_x deposition below the first 10 kg N/ha/yr.

Although increases in oxides of nitrogen could lead to increased acidification, nitrogen can also be taken up and used by plants. Studies of plant species native to Alberta indicate that, at low concentrations, NO_x may be beneficial to plants (Rochefort and Vitt 1988). However, excess availability of nutrients, including nitrogen, can lead to nitrogen

eutrophication. As such, acidification may cause shifts in species composition, abundance and biodiversity. For example, Nitrogen additions may lead to negative changes in species composition (Rocheffort and Vitt 1988) or a shift from oligotrophic to eutrophic environments.

Affects from acidification (PAI) due to the Project is predicted to affect 1,773 ha of terrestrial and wetlands vegetation, while eutrophication is predicted to affect 119 ha of terrestrial and wetlands vegetation. Assuming the area affected by eutrophication overlaps that of acid deposition, a total of 119 ha of the TASA may be simultaneously affected by acidification and eutrophication. Considering that the TASA is 484,297 ha in size, the cumulative effect represents less than 0.025% of the total area. Therefore it is not expected that cumulative effects from different air emissions (i.e., acidification and eutrophication) on terrestrial vegetation and wetlands receptors will result in environmental consequences greater than those considered for the individual air emission measures (refer to EIA, Volume 3, Section 5.5.5.3, Table 5.5-20).

References:

Rocheffort, L. and D.H. Vitt. 1988. *Effects of Simulated Acid Rain on Tomenthypnum Nitens and Scorpidium Scorpioides in a Rich Fen*. The Bryologist 91: 121–129.

1.9 Reclamation, Soils, and Landforms

76. Direct placement of soil strategy unclear.

Request:

- i. Estimate the area that would have topsoil placed directly upon it, rather than stored in the reclamation material sites.**

Response:

- i It is estimated that approximately 3,640 ha (35% of the Pierre River Mine) will be subject to direct placement of reclamation material. The remainder will be stored in reclamation material stockpiles.

Request:

- ii. Explain how biodiversity would be enhanced in the areas where direct placement is not possible.**

Response:

- ii. Direct placement is one of the many factors that contribute to biodiversity on the reclaimed landscape. There is no evidence to support that direct placement is the only link to enhanced biodiversity on the reclaimed landscape

The Reclamation Goals and Principles stated in Section 1.2 of the Closure, Conservation and Reclamation (CC&R) plans for the JME EIA Update (Shell 2008) clarify the revegetation strategy. For information on enhancing biodiversity, see Volume 5, Section 7.1.

In areas where direct placement of reclamation material is not practical, the reclaimed soil profile will be reconstructed with material from stockpiles. A nurse crop of annual barley and native forbs will be seeded according to the requirements of the target ecosite, to limit non-native species invasion, prevent erosion and encourage succession. Natural ingress from adjacent undisturbed areas is expected to occur concurrently.

Once forbs have been successfully established and erosion issues have been mitigated, vegetative stock will be planted according to the species and densities presented in Tables 27 and 28 of the CC&R plan, as adapted from the past guidelines provided by the Oil Sands Vegetation Reclamation Committee (OSVRC 1998). Revegetation strategies will be updated as required to meet current guidelines provided by Alberta Environment (AENV 2010) and future iterations of the guidelines.

Reclamation and revegetation monitoring programs will be implemented when reclamation activities begin. The objectives of monitoring programs and adaptive management are to ensure that the reclaimed areas are on a trajectory to achieving equivalent land capabilities (as required in the project approval conditions) and biodiversity parameters (including species richness) equivalent to undisturbed areas of the same target ecosite type.

Shell is taking steps to ensure that seed source and planting material is available at the time of reclamation. Shell participates in the Seed Co-operative, where the objective is to ensure that native seed and planting stock is available at the time of reclamation and that genetic diversity for native species is preserved. Shell will participate in further native seed collection programs, if necessary, to reach revegetation goals.

References:

AENV. 2010. *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2nd Edition*. Prepared by the Terrestrial Subgroup of the Reclamation Working Group of the Cumulative Environmental Management Association, Fort McMurray, AB. December 2009.

OSVRC (Oil Sands Vegetation Reclamation Committee). 1998. *Guidelines for Reclamation of Terrestrial Vegetation in the Oil Sands Region*. 48 pp + Appendices.

Shell (Shell Canada Limited). 2008. Application for Approval of the Jackpine Mine Expansion & Pierre River Mine Project Environmental Impact Assessment Update. Submitted to the Energy Resources Conservation Board and Alberta Environment. May 2008.

Request:

- iii. Explain how species richness would be enhanced with the direct placement of the topsoil and the lack of seeding forbs (other than in two shrublands).**

Response:

- iii. Ingress of native vegetation will be enhanced with the direct placement of topsoil because of the presence of viable seeds and propagules in directly placed topsoil. However, native forbs will be planted as required to meet reclamation certification targets for species richness. Species richness targets and other relevant guidelines are expected to be established by the Cumulative Environmental Management Association (CEMA) and will be required for use by operators requesting Reclamation Certification.

Request:

- iv. Describe Shell's willingness to prepare contingency plans, including sufficient reserve funds, in the event that the reclamation strategies described in the Application do not meet their intended outcomes.**

Response:

- iv. Shell Jackpine Mine and Muskeg River Mine are required to address the liability associated with all landforms during reclamation and at mine closure through the Reclamation Security bond and soon the Mine Financial Security Plan (MFSP) as will any new approved mine areas. These bond systems assess liability up to and including the point at which certification is achieved. Until certification, the MFSP requires funds to complete reclamation including any monitoring strategy that results in requirement for further management of already-reclaimed areas. In addition, Closure Conservation and Reclamation Plans for each mine are required to demonstrate contingencies of conserved materials (e.g. reclamation soils) to provide for changes to or management of reclamation areas.

Request:

- v. Describe Shell's willingness to use the ACFN and other regional Aboriginal communities as monitors of Shell's success in this matter (and others associated with the Rights held by these communities).**

Response:

- v. Shell is open to discussing the role of Aboriginal communities in monitoring reclamation success.

77. Reliance on LCCS for meeting replacement of equivalent land capability inadequate.

Request:

Explain why Shell relies solely on the LCCS system to predict equivalent land capability.

Response:

Shell and other oil sands operators are required by the conditions of their operating approval to use the Land Capability Classification System (CEMA 2006) to predict and target equivalent land capability at closure. Shell has taken steps to plan beyond this current regulatory requirement by early adoption (both on the Jackpine Mine Phase 1 site and within the closure planning for the Jackpine Mine Expansion) of soil salvage measures in more recent operating approvals that separate upland and peat soils for targeted ecosite reclamation. Shell is also actively using the

Shell is aware that the system to classify equivalent land capability is under review and the alternative methods will be used when they become available. In the meantime, Shell is actively using the revised Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region (AENV 2010) as the basis for operational closure and reclamation planning.

References:

CEMA (Cumulative Environmental Management Association). 2006. *Land Capability Classification System for Forest Ecosystems in the Oil Sands, 3rd Edition. Volume 1: Field Manual for Land Capability Determination.* Prepared for Alberta Environment by the Cumulative Environmental Management Association. Alberta Environment. 2006. Edmonton, AB. 148 pp.

AENV (Alberta Environment). 2010. *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region, 2nd Edition.* Prepared by the Terrestrial Subgroup of the Reclamation Working Group of the Cumulative Environmental Management Association, Fort McMurray, AB. December 2009.

78. Closure landscape water quality details required.

Request:

- i. Discuss how Shell plans to estimate the location of the long-term water table and seepage areas in an area when groundwater is being affected by other mines and climate change is likely but unpredictable.**

Response:

- i. Shell's closure plans consider the effects of neighbouring mining operations and climate change on local groundwater flow patterns. However, Shell recognizes that mine plans will likely undergo modification over each project's life. Because of this, Shell will continue to work with neighbouring operators to integrate our plans and conduct monitoring during and following operations. This monitoring will inform water table depths and seepage areas. This monitoring will also allow Shell to adapt its closure planning to account for climatic conditions at the time.

Climate change would predominantly affect recharge to the groundwater: in a wet environment there would be more recharge to groundwater, higher (or shallower) water table, and eventually more discharge of groundwater to streams and water bodies; in a dry environment the reverse would be true, less recharge to groundwater, lower (deeper) water table, and eventually a decrease in discharge to surface water.

Request:

- ii. Discuss how surface water would be separated from process-affected water (in the fine tailings) in the final landscape.**

Response:

- ii. There are no plans to separate process-affected water from surface waters in the final landscape. Process-affected waters and surface waters from the reclaimed landscape will be directed to the pit lakes. All sources of water, both process-affected and fresh, were incorporated into the pit lake modelling for the project, as described in the EIA, Volume 4A, Section 6.5.5.

79. Destruction of Eymundson Sinkholes inadequately assessed.

Requests:

- i. Discuss the pre - historic and historic significance of the Eymundson Sinkholes, integrating specific TK about these features into the analysis.**

Response:

A review was made of the available TK information, including ACFN (2008), and the HRIA for Shell (2007). The review did not identify any TK relating to potential pre-historic or historic significance of the Eymundson Sinkholes. If ACFN has additional specific TK related to the Eymundson Sinkholes, please provide it.

Shell (2007) considered the potential effects of the Project on the Eymundson Sinkholes in the Resource Use Assessment in EIA Volume Volume 5, Section 8.1.2. Available information on the geological and hydrogeological regimes of the Eymundson Sinkholes is presented in Section 5.4.3 of the Hydrogeology Environmental Setting Report (WorleyParsons Komex 2007).

Reference Cited:

ACFN (Athabasca Chipewyan First Nation Environmental Division). 2008. Athabasca Chipewyan First Nation Traditional Environmental Knowledge and Traditional Land Use Study for the Proposed Shell Jackpine Mine Expansion & Pierre River Mine Project.

Requests:

- ii. Discuss regional commitments, if any, to protect representative examples of these karst features. If none, what would Shell propose to be a reasonable course of action?**

Response:

There are no regional plans to preserve examples of karst features in the area of the Eymundson Sinkholes because dry and wet sinkholes (karst features) are common in this area.

The Wood Buffalo National Park in northeastern Alberta is an excellent example for karst topography. It contains “the most extensive and best developed gypsum karst topography in North America” (Mussieux and Nelson, 1998). It includes numerous sinkholes, including sinkhole lakes and heavily wooded areas of collapsed sinkholes, as well as other features such as saline springs and salt flats.

Reference:

Mussieux R. and M. Nelson. 1998. A Traveller's Guide to Geological Wonders in Alberta. The Provincial Museum of Alberta. 254 pp.

80. Reclamation of wetlands as upland forest inadequately assessed and planned.

Request:

- i. Discuss the use of the CEMA Guideline for Wetland Establishment on Reclaimed Oil Sands Leases recommendation of a watershed:wetlands ratio of 2:1 for the creation of sustainable ecosystems in the Oil Sands Region.**

Response:

- i. The 2:1 watershed to wetlands ratio presented in the Cumulative Environmental Management Association guideline (AENV 2008) was used as design guidance for the Jackpine Mine Expansion closure landscape. Further indication of appropriate ratios for the Oil Sands Region is expected to be provided in the Wetlands Policy and the requirements outlined in the policy will be followed once it is in place.

Shell suggests that establishing an appropriate ratio for wetlands is site specific rather than regional and more appropriately addressed in detailed operational plans.

References:

AENV (Alberta Environment). 2008. *Guideline for wetland establishment on reclaimed oil sands leases* (2nd Edition). Prepared by Harris, M.L. for CEMA Wetlands and Aquatics Subgroup of the Reclamation Working Group, Fort McMurray, AB. December 2007.

Request:

- ii. Present the area of wetlands in the region that would be converted into uplands.**

Response:

- ii. Shell does not have access to the data to inform the assessment of closure vegetation for all projects in the region. The closure plan presented in Appendix II (Shell 2008) is conceptual in nature and the level of detail presented in the vegetation impact tables is appropriate for this scale of assessment. Please refer to Table 17 in Appendix II (Shell 2008) for details on the alterations and losses to vegetation and wetlands types in the development area.

References:

Shell (Shell Canada Limited). 2008. *Application for Approval of the Jackpine Mine Expansion & Pierre River Mine Project Environmental Impact Assessment Update*. Submitted to the Energy Resources Conservation Board and Alberta Environment. May 2008.

Request:

- iii. Describe the decisions and cost necessary to implement the 2:1 watershed:wetlands ratio.**

Response:

- iii. As discussed in the response to Question 74i, the 2:1 watershed to wetlands ratio presented in the Cumulative Environmental Management Association guideline (AENV 2008) was used as design guidance for the Jackpine Mine Expansion closure landscape. Further indication of appropriate ratios for the Oil Sands Region is expected to be provided in the Wetlands Policy and the requirements outlined in the policy will be followed once it is in place. Shell has made the conservative assumption, for the purposes of the EIA, that some of the specific wetlands types (i.e., peatlands) lost to development will not be targeted at closure, but will be instead reclaimed to uplands types and pit lakes. This conservative assumption was made on the basis of (a) only newly started research on peatlands establishment being available at the time of the EIA and (b) that such a conservative assumption was desirable to accurately assess impacts, even though it is anticipated that many of the planned ecosite types include wetland areas.

Shell considers timely and cost effective reclamation of wetlands to be reclamation that:

- occurs in a timeframe that meets Alberta regulatory requirements
- considers input from key stakeholders
- provides a stable reclaimed landscape within an acceptable timeframe
- accomplishes all requirements at a cost that does not impede Shell and its joint venture partners from obtaining an acceptable financial return on the invested project capital cost.

These factors will therefore be the decision-making framework used to assess the cost of wetlands reclamation, once more information about the appropriate ratios are available.

81. Large reclamation knowledge gaps and complex issues related to tailings management inadequately assessed.

Request:

- i. Clearly identify the limits of demonstrated reclamation technology replace equivalent capability.**

Response:

- i. Shell is aware of the limitations of current reclamation technology and is participating in regional research programs to determine comprehensive methods of evaluating reclamation success based on equivalent land capability and the desired end land use. The C C&R Plan in Appendix II of the 2008 EIA Update (Shell 2008) describes risks and mitigation strategies, and has been developed with the current available best practices and guidelines. Reclamation programs will be adjusted during operations as technology becomes available through regional and site-specific monitoring and research.

References:

Shell (Shell Canada Limited). 2008. *Application for Approval of the Jackpine Mine Expansion & Pierre River Mine Project Environmental Impact Assessment Update*. Submitted to the Energy Resources Conservation Board and Alberta Environment. May 2008.

Request:

- ii. Provide examples in the mineable Oil Sands Region where restoration (rather than mere reclamation) is possible, including an order of magnitude estimate of the cost compared to current methods.**

Response:

- ii. The process of reclamation shares many similar attributes with restoration, as documented in the Society for Ecological Restoration's Primer (SERI 2004). However, restoration implies the return of the land to conditions identical to those present prior to development. Shell acknowledges that the landscape cannot be returned to its historical trajectory because of changes in landforms and landscapes as a result of mining activities. Restoration on the post-mining landscape is only possible in areas where the original topography remains unchanged.

Two examples where the topography is not altered and may be subject to restoration at closure are:

- plant site or facility areas; and
- areas that have been cleared of vegetation and not subject to mine development.

The costs to restore these areas would be the same as for reclamation.

Shell does not have information to inform the cost to replace the original topography following mining activities. Shell conducted the assessment and designed the mine plan with the assumption that the topography (i.e., historical trajectory) will not be restored to its original state. Timely and cost effective reclamation therefore been considered on the basis that it:

- occurs in a timeframe that meets Alberta regulatory requirements
- considers input from key stakeholders
- provides a stable reclaimed landscape within an acceptable timeframe
- accomplishes all requirements at a cost that does not impede Shell and its joint venture partners from obtaining an acceptable financial return on the invested project capital cost

References:

SERI (Society for Ecological Restoration International). 2004. The SER International Primer on Ecological Restoration Society for Ecological Restoration International Science & Policy Working Group Version 2, October, 2004

Request:

iii. Discuss the issues specific to stabilization and reclamation of non-segregating tailings.

Response:

iii. Shell has considered the rate and pattern of densification of tailings deposits in detail, with an objective of achieving a densified and stable deposit quickly enough to meet Directive 074 requirements for trafficability.

The sand and overburden capping methods described in the JME application and in the Shell Albian Sands Jackpine Mine 2010 Directive 074 Plan are designed to apply constant compression to tailings deposits such as non-segregating tailings (NST) and thickened tails (TT), and drainage systems have been designed in the closure landscape to collect any process-affected water and direct it through the drainage system (wetlands and pit lakes) for remediation. These measures are designed to reduce possible compressibility, and all reclaimed tailings surfaces will be monitored closely for potential settlement.

Reclamation activities, beginning with overburden placement, will begin once a sand cap has been placed and any remaining surface waters have been expressed, evaporated or drained. Overburden will be placed at an average depth of 3 m and contoured to achieve the final closure drainage topography presented in Figure 4 in Appendix II

(Shell 2008). Reclamation material will be placed on the contoured surface according to the soil prescriptions outlined in Tables 28 and Table 29 (Appendix II). Revegetation will proceed according to the planting prescriptions outlined in Tables 28 and 29 to achieve the target ecosites presented in Figure 14 (Appendix II). Reclamation and revegetation monitoring will be initiated and Shell will adaptively manage reclaimed areas to ensure ecosystems are on a trajectory towards achieving land capability classification targets. The reclamation and closure activities described above are estimated to require an additional 10 years after overburden placement.

References:

Shell (Shell Canada Limited). 2008. *Application for Approval of the Jackpine Mine Expansion & Pierre River Mine Project Environmental Impact Assessment Update*. Submitted to the Energy Resources Conservation Board and Alberta Environment. May 2008.

Request:

- iv. Review impact assessments and confidence ratings based on demonstrated reclamation success.**

Response:

- iv. As discussed in the response to Question 76v, Shell has considered the rate and pattern of densification of tailings deposits in detail, with an objective of achieving a densified and stable deposit quickly enough to meet Directive 074 requirements for trafficability. The sand and overburden capping methods described in the PRM application and in the Shell Albian Sands Jackpine Mine 2010 Directive 074 Plan are designed to apply constant compression to tailings deposits, and drainage systems have been designed in the closure landscape to collect any process-affected water and direct it through the drainage system (wetlands and pit lakes) for remediation. These measures are designed to reduce possible compressibility, and all reclaimed tailings surfaces will be monitored closely for potential settlement

Request:

- v. Discuss how Shell will manage tailings to develop strength to allow timely capping and meet reclamation and closure requirements.**

Response:

- v. Strength development in tailings deposits is described in detail in the Shell Albian Sands Jackpine Mine 2010 Directive 074 Plan (approved in December 2010) and Supplemental Information Requests submitted in May 2010.

In summary, Shell has stated that the majority of tailings densification happens within the first five years after deposition, and that the rate with which rapid densification

occurs within the first year is a good indicator for whether tailings strength is proceeding according to plan or requires remediation. In addition to densification of tailings products, a sand cap is applied to facilitate water expression and provide a trafficable surface.

Should remediative actions be required, they may include adjustments to process equipment, treatment of tailings at the deposition line and/or drainage enhancement measures such as installation of wick drains, use of mechanical equipment means to promote dewatering and drying, and placement of sand layers to promote consolidation and fluid drainage.

Request:

- vi. Discuss how Shell will meet the requirement of having tailings with low compressibility so as to minimize settlement and not disrupt the closure landscape.**

Response:

- vi. As discussed in the response to Question 76iii, Shell has considered the rate and pattern of densification of tailings deposits in detail and the sand and overburden capping methods described in the JME application and in the Shell Albian Sands Jackpine Mine 2010 Directive 074 Plan are designed to apply constant compression to tailings deposits.

Drainage systems have been designed in the closure landscape to collect any process-affected water and direct it through the drainage system (wetlands and pit lakes) for remediation. These measures are designed to reduce possible compressibility, and all reclaimed tailings surfaces will be monitored closely for potential settlement.

Request:

- vii. Discuss how water quality and salt load from the de-watering tailings will be managed to not create large areas of saline soils in the reclaimed landscapes.**

Response:

- vii. Minimizing salinity issues on the closure landscape is a design objective and consideration of the Closure Drainage Plan. This plan is described fully in the 2008 EIA Update, Appendix I, with design objectives described in Section 2.1.

Request:

- viii. Discuss uncertainties regarding tailings reclamation, including the risk of failure with tailings pond dikes and the risk that reclaimed tailings will not support ecosite phases.**

Response:

- viii. Reclamation of tailings has several stages, all of which have been considered in terms of supporting development of ecosites on trafficable, stable landscapes. The response to Question 20iii considered the state of tailings ponds dykes at the time of reclamation and noted that to be closed, structures must have reached a point at which fluid-containing structures are either decommissioned as fluid retention structures (e.g. by decommissioning a dyke wall when the tailings content has consolidated and will not move in the External Tailings Facilities) or designed into the landscape such that no fluid-retention structures are required (e.g. pit lakes at below original topography). At closure all fluid tailings will be drained from the ETF and the surface elevation will be contoured to drain an average overland slope of 0.5% to constructed wetlands areas. The removal of fluid tailings and the re-contouring of the ETF slopes eliminate any risk of dyke failures post closure activities.

Tailings reclamation surfaces consist of a number of layers and structures, to provide the conditions to support suitable ecosite phases (and it should be noted that the low-lying topography of reclaimed tailings cells makes some upland ecosite types clearly unsuitable, as designed into the Closure, Conservation and Reclamation [CC&R] Plan). During mine closure all mine tailings in external ponds and in-pit depositions are capped with sand and overburden. The sand will be sourced from clean tailings sand process streams, and overburden will be sourced from overburden storage areas and placed onto trafficable areas to a minimum average depth of 3m. The overburden cap will be contoured to grade, to provide channels for drainage and to provide mesotopographical features for reclamation activities. On completion of overburden capping, reclamation materials will be placed according to prescribed replacement depths.

Therefore before any reclamation material is placed, successive layers of material have been applied to tailings areas to provide trafficable surfaces, drainage systems and spatial separation from the tailings. Once ecosites have been revegetated according to the CC&R plan, the application assumes an extensive period of monitoring and management intervention if it is clear that ecosites are not developing as planned.

Request:

- ix. **Compare and contrast the use of dry tailings technologies versus thickened tailings for the PRM. Include reclamation success in the discussion.**

Response:

Shell's Tailings Management Plan for the Pierre River Mine will use a portfolio of fines management techniques including:

- Permanent Thickened Tailings (TT) deposits,
- Temporary tailings drying areas using flocculant polymers,
- Centrifugation of tailings and subsequent drying, and
- NST – Non Segregating Tailings (NST) technology

In the case of permanent TT and NST areas, tailings are deposited and reclaimed by covering with suitable depths of sand, overburden, soil and vegetation as discussed in the responses to 76iii, 76v and 76viii.

When polymeric flocculant or centrifugation drying techniques are used, tailings are spread in thin lifts over large areas and are worked mechanically to allow drying. The dried tailings material is then hauled and buried in pit or in external overburden disposal areas before capping and reclamation materials are applied.

Whether tailings area treated by drying technologies or by deposition, drainage and capping technologies, reclamation activities have been designed to provide a successful venue for the closure drainage and ecosite plans provided in Appendix I and II of the Jackpine Mine Expansion and Pierre River Mine Project EIA Update (Shell 2008). It is not anticipated that use of dry tailings technologies will change the terrestrial closure landscape for the Jackpine Mine Expansion, as they are disposed of in existing landforms during their planned construction and use periods. The key landscape change is that the use of dry tailings technologies is anticipated to move fluid tailings inventories into terrestrial closure landforms and out of pit lakes, thereby changing the anticipated substrate and water quality for lake systems

Reference:

Shell (Shell Canada Limited). 2008. *Application for Approval of the Jackpine Mine Expansion & Pierre River Mine Project Environmental Impact Assessment Update*. Submitted to the Energy Resources Conservation Board and Alberta Environment. May 2008.

Request:

- x. **Identify any changes Shell is considering that would eliminate external tailings ponds and the long-term storage of wet tailings in the reclaimed landscape and in end pit lakes.**

Response:

As discussed in the response to Question 5vi, the ERCB approved Shell's Directive 074 plans for the Muskeg River Mine and Jackpine Mine – Phase 1 in September 2010 and December 2010, respectively. Now that Shell has approved Directive 074 plans for its base operations, the current focus is on expanding the plans to consideration of technologies that address the fate of fluid tailings in the closure landscape (such as Atmospheric Fines Drying, centrifugation and other methods) and these are being worked on for all mine areas including the Jackpine Mine Expansion. Shell is supportive of Directive 074's focus on minimizing and eventually eliminating long-term storage of fluid tailings.

82. Traditional land assessment does not meet the Terms of Reference.

Request:

Discuss how Shell intends to comply with the Terms of Reference with regards to consultation with the ACFN on traditional use and impacts of the PRM.

Response:

Shell has met the terms of reference. Shell has made best efforts to collect and use ACFN TK/TLU information in the EIA. Shell requested and funded the collection of TK/TLU information from ACFN. Shell and ACFN entered into a TK Sharing Agreement. Shell and ACFN have a TK Collection and Use agreement that sets out how TK/TLU will be collected and used. ACFN completed a 2008 TLU Study however ACFN would not allow Shell to incorporate the information into the EIA. Shell has also funded a Supplementary Study that remains incomplete.

Any TK/TLU that Shell receives subsequent to this response will be provided directly to the JRP and appropriate regulators to be considered in their public interest decision. Shell will also consider the information in project planning and design as set out in the TK Collection and Use agreement.

83. TK and TLU not seriously considered in the assessment.

Request:

- i. Conclude the work on TK/TLU and incorporate into the EIA before proceeding with the application.**

Response:

- i. The EIA was deemed complete in 2010. Shell continues to await the completion of ACFN's Supplementary TK/TLU Study. Also see above.

Request:

- ii. **Clarify how the TLU and TK information has been considered in the project planning.**

Response:

- ii. Shell has yet to receive TLU/TK information from ACFN. Also see above.

Request:

- iii. **Clarify how the TLU and TK information provided by the ACFN will be considered in the project operation.**

Response:

- iii. Shell and ACFN have a TK Sharing agreement and a Final Scope of TK Collection and Use that sets out how the information will be collected and used.

Request:

- iv. **Clarify whether the TLU and TK work is complete.**

Response:

- iv. Shell is waiting for the TLU/TK Study results from ACFN.

Request:

- v. **Identify the specific instances where the TK information provided both corresponds and does not correspond with scientific information in the EIA.**

- v. Traditional Knowledge (TK) and Traditional Land Use (TLU) information was integrated into the EIA as follows:

- Consumptive use of plants: Terrestrial Vegetation, Wetlands and Forest Resources (Volume 5, Section 7.3.3), and Human Health (Volume 3, Section 5.3);
- Medicinal use of plants: Terrestrial Vegetation, Wetlands and Forest Resources (Volume 5, Section 7.3.3), and Human Health (Volume 3, Section 5.3);

- Spiritual use of plants: Terrestrial Vegetation, Wetlands and Forest Resources (Volume 5, Section 7.3.3), and Socio-Economics (Volume 5, Section 8.7);
- Contamination of traditionally used plants: Air Quality (Volume 3, Section 3.3), and Human Health (Volume 3, Section 5.3);
- Wildlife and wildlife habitat: Wildlife and Wildlife Habitat (Volume 5, Section 7.3.4);
- Consumptive use of wildlife (hunting and trapping): Wildlife and Wildlife Habitat (Volume 5, Section 7.3.4).

Integration of TK into the Surface Water Hydrology Assessment is summarised in Table 6.4-6 (Volume 4, Section 6.4.4). Integration of Traditional Knowledge into the Surface Water Quality Assessment is summarised in Table 6.5-3 (Volume 4, Section 6.5.4). The integration of TK into the Fish and Fish Habitat assessment is found in Volume 4, Section 6.7.4.

Because TK and TLU information were considered and factored into the Project's potential effects on the above components, the information complemented the scientific information.

Response:

Request:

- vi. Identify how Shell will address ACFN concerns about TLU in the project area.**

Response:

- vi. TLU and TK information, including information on changes to land use, additional valued ecosystem components and other information will all be submitted to the regulators. All of this information, including Shell's EIAs and other evidence, will be tested in front of these regulators, and a decision will be made regarding the likely significance of environmental impacts, including impacts to the exercise of Aboriginal and Treaty Rights. Shell intends that TLU / TK information be provided to relevant Crown decision makers to ensure that a full consideration of impacts to Aboriginal and Treaty Rights is undertaken prior to any decisions being made regarding the Projects.

Shell has offered to negotiate an appropriate mitigation agreement with ACFN based on the concerns and issues raised over the past 4 years of consultation.

Issues would be addressed in a collaborative manner through ongoing consultation.

The Crown may also make use of the public regulatory hearing and environmental review process as a further means to ensure that Aboriginal concerns are heard, and where appropriate, accommodated.

Request:

- vii. After reconsidering the ACFN's TK submission, re-evaluate how the project would impact the ACFN's ability to exercise their Rights.**

Response:

- vii.** At the time of writing, the ACFN's project-specific TK submission has not been received. When the study becomes available, it will be used to update the potential effects of the Project on the exercise of ACFN's rights as they relate to traditional activities and the use of environmental receptors that are involved in the exercise of ACFN's rights.
-

84. Details on the loss of traditional territory required.

Request:

Clarify whether any identified sites of traditional significance will be avoided or impacts upon them mitigated.

Response:

For the period of operations, it is assumed that traditional land uses will be precluded from the Project development area. Therefore, the effect of the Project on traditional uses within the development area is expected to be high for 25 to 50 years. However, after reclamation, the area is expected to support many of the traditional land uses that occurred in the Base Case.

Disturbances to the ACFN traditional territory under the Base Case represent 10% of the territory. Additional disturbances as a result of the Project are predicted to represent 1% of the ACFN traditional territory. Under the PDC, disturbances are predicted to represent 14% of the total area of the ACFN traditional territory. Shell's EIAs have also assessed the potential impacts to the environmental resources that underlie the ACFN's traditional activities.

Berry harvesting areas on RFMA #s 1716 and 1714 that are within the Project development area will be unavailable for plant harvesting during the operational phase of the Project. Upon reclamation, RFMA #1714 will undergo increases in high and low traditional plant potentials of 3 and 10% respectively over Base Case. RFMA #1714 will experience a loss of 12% in moderate plant potential over Base Case (based upon total RFMA area). Upon closure, RFMA #1716 will experience a decrease of less than 1 and 3% for high and moderate traditional plant potential, respectively, over Base Case (based upon total area of RFMA). RFMA #1716 will experience an increase in low traditional plant potential of 3% over Base Case (based upon total RFMA area).

The operational phase of the Project is expected to result in a loss of wildlife habitat for RFMA #s 1716 and 1714. Upon reclamation, moose habitat is expected to increase by 1 and 14% for RFMA #s 1716 and 1714 respectively (compared to Base Case). Fisher habitat is expected to decrease by 1% for RFMA #1714 and by 6% for RFMA #1716. Beaver habitat is expected to increase by 6 and 4% for RFMA #s 1716 and 1714 respectively. Lynx habitat is expected to increase by 1% for RFMA #1714, and decrease by 6% for RFMA #1716.

Existing developments have impeded access to RFMA #1716, the holder of which now requires road access due to age. Shell currently facilitates access across its Project areas to maintain trapper access to their traplines. The main cabin on RFMA #1716 and a cabin on RFMA #1714 are within the Project development area and will need to be moved.

The Kearl Lake Levee will add an additional 13 ha disturbance to RFMA #2172 and an additional 79 ha disturbance to RFMA #1714. The additional disturbance represents less than 1% of the area of each of the two RFMAs. The 77 ha of submerged shoreline is not considered disturbed for TLU purposes as it will evolve into a functioning littoral zone over time.

During the HRIAs that were conducted for the Project no burial grounds or campsites were identified or recorded. Additionally, no diagnostic material was recovered from any of the sites that were recorded. Mitigation recommendations were forwarded to Alberta Culture and Community Development for review.

Shell understands the development area is of traditional significance to ACFN, as it is located within the ACFN traditional territory. The project will result in a temporary loss of 1% of the ACFN traditional territory, plus changes due to air emissions and surface water discharges. The mitigation measures outlined in the EIA reduce effects to the environment in the area of traditional significance to ACFN.

While Shell's EIA has assessed the potential impacts to the environmental resources that underlie the exercise of ACFN's Aboriginal and Treaty rights, Shell welcomes any further information ACFN might have in terms of details around sites of traditional significance that might further inform the predictions contained in Shell's EIA, and which ACFN wish to have considered by the relevant Crown agencies as part of their decision-making process.

85. Cumulative impacts to traditional users not fully addressed.

Request:

- i. Address the impact of the loss of traditional land use of the PRM on traditional uses by the ACFN and their ability to exercise their Rights.**

Response:

- i. Overall, very little of ACFN's traditional land use area is expected to be lost during operations, and accordingly, there are no likely significant adverse impacts to the overall use of those lands and associated exercise of rights. During the operational life of the mine, there will be periods when it will not be possible to exercise traditional activities within the terrestrial LSA. A review of available ACFN TLU mapping information which shows the "core" areas of ACFN's TLU area, as well as the 2003 ACFN TLU study, both of which were filed in the Total Joslyn North Mine JRP public hearing, show that the vast majority of ACFN traditional use areas (including game and fowl hunting, berry and medicine hunting, and traditional and spiritual sites) occur in the vicinity of Fort Chipewyan and the Richardson Backcountry. The 2008 TLU information from ACFN, based on interviews with participants chosen based on proximity to the Shell leases does disclose some traditional use areas in and around Kearl Lake. However, the vast majority of ACFN's self identified traditional use areas do not fall within the mineable oil sands area, but rather fall in much closer proximity to the community of Fort Chipewyan, Lake Athabasca and the Richardson Backcountry. Based on the publicly disclosed extent and distribution of ACFN's traditional use areas, there is not likely to be any significant adverse impacts to the exercise of ACFN's Aboriginal rights as they relate to traditional activities.

Request:

- ii. Re-assess the cumulative impacts from the Pierre River Mine Project and nearby operations, using actual data from reclamation efforts from these neighbouring operations. After identifying the gaps between what was promised and what was delivered, identify what mitigations Shell would consider. Use a pre-industrial baseline for the assessment.**

Response:

- ii. Please refer to Section 1.0 of the JME Technical Review response document for a discussion on the use of a pre-development baseline for the assessment.

Shell cannot speak to the status or progress of reclamation activities for other operators at this time. Alberta Environment anticipates access to the Oil Sands Information Portal to be public towards the end of 2011, at which time cumulative data on development and reclamation activities will be available for all oil sands mine operators. For the Application Case, Shell's EIA conservatively assumes PRM, JME and JPM – Phase 1

are the only projects reclaimed. By excluding other operator's reclamation activities, the assessment overestimates the loss of terrestrial resources in the region.

At this stage of development of the Muskeg River Mine and Jackpine Mine – Phase 1, closure and reclamation activities are focused on conservation activities for soils and propagative material. Salvage of soils and development of Reclamation Material Stockpiles (RMS) is on schedule with reclamation requirements for areas disturbed by mining activities, and permanent reclamation activities are underway at the Muskeg River Mine as per the data presented in the 2010 Annual Environment Report submitted to Alberta Environment on April 15, 2011.

Request:

- iii. Identify how Shell will address the potential liabilities if the planned reclamation measures fail to meet regulatory requirements and the needs of Rights-bearing Aboriginal communities.**

Response:

- iii. The regulator sets out clear direction on appropriate reclamation standards, measures and criteria. These will be established in consideration of Aboriginal Rights and potential impacts. Shell will comply with the measures set forth by the regulator.

Request:

- iv. Assess how the ACFN's ability to exercise their Rights would be impacted by having to carry out their traditional practices in a reclaimed landscape that is vastly different than the pre-industrialization landscape.**

Response:

- iv. On a local study area basis, during the operational life of the mine, there will be periods when traditional activities will not be possible on active portions of the Project footprint. However, the vast majority of ACFN's self identified traditional use areas do not fall within the LSA, but rather fall in much closer proximity to the community of Fort Chipewyan, Lake Athabasca and the Richardson Backcountry. Based on the publicly disclosed extent and distribution of ACFN's traditional use areas, there is not likely to be any significant adverse impacts to ACFN's traditional activities. Shell's reclamation goal is to achieve maintenance-free, self-sustaining ecosystems with a capability equivalent to pre-development conditions (i.e., prior to the development of this project). End land use objectives will be developed in consultation with stakeholders, including ACFN, and will provide for traditional land uses. Therefore, very little of ACFN's traditional land use areas will be reclaimed to a state that would be vastly different than a pre-industrialized landscape.

86. Industrial activities directly and indirectly impact on TLU and practice of Aboriginal and Treaty rights.

Request:

- i. Assess the direct and indirect effects of the PRM in combination with all other regional projects on the well-being and culture of the ACFN. Take into consideration the incremental and cumulative effects of industry and other activities in the region.**

Response:

- i. Shell's EIA has predicted no likely significant adverse environmental impacts to the biophysical components that ACFN rely upon (either directly or indirectly) for the exercise of Treaty and Aboriginal Rights. Also, the human health risk assessment completed as part of the EIA concluded that the projects are not predicted to contribute appreciably to health risks in the region and that cumulative health risks associated with the projects are not expected to result in a measurable increase in health effects.

Shell will continue to work with the ACFN IRC to determine how best to mitigate the potential social and cultural effects of development, as appropriate. Shell also supports a number of cultural retention and other initiatives, which aim at helping Aboriginal communities maintain their social cohesion and unique characteristics.

As community initiatives come forward, Shell will assist and contribute where appropriate.

Request:

- ii. Assess the direct and indirect effects of the PRM in combination with all other regional projects (in the past, present, and future) on the ability of the ACFN to practice their Aboriginal and Treaty rights.**

Response:

- ii. Shell's EIAs contain a cumulative effects assessment based on a Planned Development Case (which includes past, present and future publicly disclosed projects), that assesses the significance of environmental impacts on the vast majority of environmental receptors and indicator resources that underlie the exercise of ACFN treaty and Aboriginal rights. By assessing the likely significance of impacts to the environmental resources relied upon by ACFN in the exercise of Treaty and Aboriginal Rights, one is able to extrapolate the significance of impacts to the exercise of those rights as they relate to the use of those resources. In combination with the available TLU and TEK information incorporated in the EIA, there is currently sufficient information to allow for the JRP to determine the impacts on the exercise of ACFN Aboriginal Rights as

they relate to the use of the resources assessed in the EIA. Shell submits that information regarding impacts to these environmental resources will allow the JRP to fully consider how the exercise of ACFN's Aboriginal rights may be impacted by any decisions or recommendations made by the JRP.

87. HHRA conclusion unclear, with details lacking.

Request:

- i. Identify who decides what is a 'noticeable increase' in health risks (or lack thereof), and how a 'noticeable increase' is defined.**

Response:

- i. The term "noticeable increase" was used in Section 5.1 (Environmental Health Conclusions), Volume 3 of the EIA. Its use was intended to describe the potential increase in health risks associated with the future emission sources in the region, including the Project. The statement with respect to "noticeable increase" was described further by the following sentence: "The changes between the Base Case and Application Case health risks are generally very small, suggesting that the Project is not predicted to contribute appreciably to health risks in the Oil Sands Region." (Section 5.1.1.1, Volume 3, EIA). In the context of this section (i.e., "Environmental Health Conclusions"), the term "noticeable" was simply intended for descriptive purposes and its use was based on the professional judgment of the health risk assessment team.

Any increase in chemical exposure (either by air concentration or daily dose) is associated with an increase in health risk. These changes are defined, in part, by increases in air concentrations, water concentrations, soil concentrations, or biotic tissue concentrations. The objective of the HHRA was to quantify these health risks and to determine whether or not changes in environmental concentrations and associated health risks could result in a measurable health effect. The HHRA concluded that, in spite of increases in certain health risks, the Project's emissions alone and in combination with other sources of COPCs are not expected to result in measurable, adverse health effects.

Although certain health risks were predicted to increase as a result of the Project's emissions alone or in combination with other sources of COPCs, measurable health effects were not predicted in the HHRA because:

- The predicted health risks, expressed as risk quotients (RQ values) for the non-carcinogens and incremental lifetime cancer risks (ILCR values) for the

carcinogens, under the Application Case and Planned Development Case (PDC) remained below 1.0, indicating that chemical exposures were not predicted to exceed the health-based exposure limits; or

- The weight-of-evidence indicates that the predicted health risks are elevated (above 1.0) due to the degree of conservatism incorporated in the derivation of the exposure limits and/or exposure estimates for the COPC or mixture.

Request:

- ii. **Identify who, if anyone, is monitoring the overall health risks and health risks to specific groups of people in the region including First Nation communities, and what is being done to address the existing and potential health risks.**

Response:

- ii. Alberta Health Services is monitoring the health of people in the Oil Sands Region.

For its part, Shell will continue to:

- actively participate in the WBEA and the TEEM program, both of which are related to the monitoring and assessment of air quality in the Athabasca oil sands;
- work with AENV, WBEA, RAMP and all its neighbours to understand regional monitoring requirements; and
- participate in the Human Exposure Monitoring Committee (which oversees the Human Exposure Monitoring Program or HEMP).

It is also Shell's understanding that the Province remains committed to undertaking a baseline health study for the community of Fort Chipewyan.

88. Conservative assumptions not fully incorporated into the HHRA.

Request:

Re-assess the uncertainties in the HHRA, specifically in those areas where conservatism has not been applied in the HHRA.

Response:

In their discussion of Question 88, the reviewers gave three examples of how the HHRA may not have been sufficiently conservative:

1. The exclusion of approximately 250 chemicals from the HHRA;

2. The absence of a discussion on the potential synergistic effects of chemical mixtures; and,
3. The use of surrogate chemicals in the HHRA.

The statement that approximately 250 chemicals were excluded from the HHRA is incorrect. The initial emissions profile (or chemical inventory) consisted of 393 chemicals (see Table 5.3-1, p.5-27, Volume 3), most of which were assessed in the HHRA. Of the 393 chemicals, 35 chemicals were not retained for quantitative analysis in the HHRA for reasons explicitly stated on page 5-35 of the HHRA.

Potential interactions between chemicals were discussed in the HHRA (Volume3, Section 5.3.2.3). Given that chemical exposures will not occur in isolation, the potential health risks associated with mixtures of the COPCs were assessed in the HHRA. Although the interaction between chemicals can take many forms (e.g., additivity, potentiation, antagonism, synergism), additive interactions were assumed for the HHRA based on Health Canada's recommendations (Health Canada 2009). Additive interactions apply most readily to chemicals that are structurally similar, act toxicologically through similar mechanisms, or affect the same target tissue in the body (i.e., share commonality in effect) (Health Canada 2009). As well, the U.S. EPA (2000) suggests that the assumption of additivity be made for low exposure levels when no interaction information is available since the likelihood of significant interaction at these exposure levels is usually considered to be low. For higher exposure levels, or when adequate data on interactions suggests other than additivity at low exposure levels, the U.S. EPA (2000) indicates that the assessment should attempt to account for the other forms of interaction. Types of interactions among mixture components that can affect toxicologic response to the whole mixture include:

- chemical-to-chemical interactions,
- toxicokinetic interactions, and
- toxicodynamic interactions.

The impact of these constituent interactions on toxicologic responses can be less than additive (e.g., antagonistic) or greater than additive (e.g., synergistic). Given that the exposure levels predicted as part of the assessment were typically low, adequate data on the interactions between the COPCs was not available, and Health Canada recommends summing the risk estimates for COPCs determined to have similar target tissues and mechanisms of action, the HHRA assumed additive interactions between the COPCs with the same endpoint of concern (according to the exposure limit).

For those chemicals for which exposure limits had not been developed or recommended by the various regulatory or reputable scientific agencies, surrogate chemicals were identified. This step relied on the toxicological principle that states that the molecular structure of a chemical has a distinct bearing on its reactivity, biological activity and toxicity. The principle allows for the toxicity of a chemical for which little or no toxicological information exists to be predicted on the basis of information available on another chemical

of similar molecular structure. The second chemical is termed a “surrogate”. For example, a health-based exposure limit for carbonyl sulphide (COS) was not available at the time of the assessment, but a health-based exposure limit was available for a suitable surrogate: carbon disulphide (CS₂). Therefore, carbonyl sulphide was assessed using the exposure limit for carbon disulphide.

Without the use of a surrogate, carbonyl sulphide could not have been assessed as part of the HHRA. On this basis, use of surrogates could be considered a conservative approach. There is, however, a moderate degree of uncertainty associated with this assumption due to the lack of toxicological information on carbonyl sulphide. Carbonyl sulphide could be less toxic than the assumed surrogate (carbon disulphide), making the use of an exposure limit developed from toxicological information on carbon disulphide conservative; or, carbonyl sulphide could be more toxic than the assumed surrogate (carbon disulphide), reducing the degree of conservatism associated with the assumption.

The former scenario is more likely as the various regulatory or reputable scientific agencies from which the exposure limits were obtained have each developed a list of chemicals that poses the greatest expected risk to public health. Health Canada and Environment Canada have developed two tiers of Priority Substances Lists (PSLs). The First Priority Substances List (PSL1) represents those chemicals determined to be "toxic" to human health (Health Canada 2008), while the Second Priority Substances List (PSL2) represents those chemicals “that may contaminate the environment and cause adverse effects on the environment and/or on human health” (Health Canada 2004). As a result, it is likely that the chemicals for which toxicological information is limited or lacking are less toxic than those for which exposure limits have been developed.

Uncertainty can surround the prediction of any health risks, regardless of type or source, and can confound the interpretation of the meaning and significance of any health risks that might be revealed by an HHRA. Whenever possible, the uncertainty is accommodated through the use of assumptions which typically embrace a certain degree of conservatism and are often intentionally selected to represent reasonable ‘worst-case’ conditions. The overall uncertainty associated with the HHRA is considered to be low. Thus, it is unlikely that the potential health risks identified by the assessment have been understated.

References:

- Health Canada. 2004. *Health-Based Guidance Values for Substances on the Second Priority Substances List*. ISBN: 0-662-37275-1.
- Health Canada. 2008. *First Priority Substances List (PSL1) Assessments*. Last updated: March 4, 2008. Accessed: December 20, 2010.
- Health Canada. 2009. *Federal Contaminated Site Risk Assessment in Canada. Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA) Version 2.0*. Prepared by: Contaminated Sites Division, Safe Environments Programme. May 2009.

U.S. EPA. 2000. *Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures*.

89. Acrolein assessment flawed.

Request:

- i. Discuss and address the inaccuracies in the airborne acrolein concentrations in the 2005 Golder report and re-evaluate the HHRA for acrolein.**

Response:

- i. In 2005, a two-part acrolein monitoring program was completed at the Suncor and Albian Sands facilities and in the communities of Fort McKay and Fort McMurray (Golder 2005).

A scoping sampling program was initially carried out between June 13 and 17, 2005 to determine the sample volume required to quantify ambient acrolein concentrations in the region. Fifteen samples were collected during the scoping sampling program. Sampling times ranged from 49 minutes to 15 hours as a result of the battery life for the sampling pumps. The shorter the sampling time, the lower the sample volume, and the higher the estimated Method Detection Limit (MDL) for acrolein. Acrolein concentrations were below the MDL of the laboratory analysis in all samples collected for the scoping program, where the MDL ranged between 0.08 $\mu\text{g}/\text{m}^3$ (at Fort McKay WBEA station) and 20 $\mu\text{g}/\text{m}^3$ (at Suncor Steepbank Mine). The MDL of 20 $\mu\text{g}/\text{m}^3$ was based on the shortest sampling time of 49 minutes. The second highest MDL of the scoping sampling program was 4.0 $\mu\text{g}/\text{m}^3$. A geometric mean MDL of 0.85 $\mu\text{g}/\text{m}^3$ was calculated for the scoping sampling program. Because this sampling program revealed that the sample volumes were not sufficient to accurately quantify ambient acrolein concentrations in the region (all samples were below the MDL), the subsequent comprehensive program focused on collecting larger sample volumes (bearing in mind any power source limitations).

The comprehensive sampling program took place between June 27 and July 2, 2005, during which time a total of 67 samples were collected. Sampling times ranged from 3 to 32 hours. Again, acrolein concentrations were below the MDL of the laboratory analysis in all samples collected. In the comprehensive sampling program, the MDL ranged between 0.04 and 2.7 $\mu\text{g}/\text{m}^3$, with the geometric mean MDL estimated to be 0.26 $\mu\text{g}/\text{m}^3$.

Because of the difficulties associated with small sample volumes and subsequently high MDLs experienced in the scoping sampling program, the HHRA focused its

discussion of ambient acrolein concentrations in the Oil Sands Region on those samples collected as part of the comprehensive sampling program. Had the HHRA considered the combined dataset for the scoping and comprehensive sampling programs, the MDL would have ranged between 0.04 and 20 $\mu\text{g}/\text{m}^3$, with the geometric mean MDL estimated to be 0.33 $\mu\text{g}/\text{m}^3$.

The highest 1-hour acrolein concentration at the maximum point of impingement (MPOI) along the PRM fence-line was 2.4 $\mu\text{g}/\text{m}^3$. This predicted ground-level air concentration is above most of the MDLs reported in the acrolein monitoring program.

In Fort McKay, ambient acrolein concentrations were below the range of MDLs in the three samples collected as part of the scoping program (0.08 to 0.65 $\mu\text{g}/\text{m}^3$), and the MDL in the three samples collected as part of the comprehensive program (0.05 $\mu\text{g}/\text{m}^3$). The highest predicted 1-hour acrolein concentration at Fort McKay under the Base Case of the HHRA was 1.2 $\mu\text{g}/\text{m}^3$. Ambient acrolein concentrations were also below the MDL of the laboratory analysis in all samples collected in Fort McMurray, where the MDL ranged between 0.05 and 0.75 $\mu\text{g}/\text{m}^3$. The highest predicted Base Case 1-hour acrolein concentration at Fort McMurray was 0.88 $\mu\text{g}/\text{m}^3$. In both communities, acrolein concentrations were predicted to be above the reported MDL. Furthermore, potential health risks to people residing within these communities were assessed in the HHRA using the highest predicted 1-hour acrolein concentration of each of the communities within the given lifestyle category (i.e., Aboriginal resident or community resident). As such, the potential health risks to people living in Fort McKay and Fort McMurray from the short-term (acute) inhalation of acrolein were based on the concentration of 1.2 $\mu\text{g}/\text{m}^3$ predicted for Fort McKay. On this basis, the ground-level air concentrations of acrolein predicted as part of the EIA for the Project probably embraced a certain degree of conservatism.

The potential short-term (acute) health risks associated with acrolein exposure can be re-evaluated, not because of “inaccuracies in the airborne acrolein concentrations in the 2005 Golder report”, but because of revisions to the exposure limit used in the acute inhalation assessment for acrolein. In the HHRA, the acute inhalation assessment for acrolein was based on the OEHHA acute Reference Exposure Level (REL) of 0.19 $\mu\text{g}/\text{m}^3$. For the purpose of the HHRA, the OEHHA REL was adjusted to 0.29 $\mu\text{g}/\text{m}^3$ using a time-concentration-response relationship value specific to acrolein, instead of the generic value applied by the OEHHA for all irritants. The OEHHA has since updated the acute REL for acrolein to 2.5 $\mu\text{g}/\text{m}^3$ (OEHHA 2008). This represents a 13-fold increase over the original OEHHA REL and a 9-fold increase over the adjusted OEHHA REL used in the HHRA.

The highest 1-hour acrolein concentration specifically relevant to the PRM (i.e., 2.4 $\mu\text{g}/\text{m}^3$ at the PRM fence-line) is not expected to exceed the 2008 OEHHA REL. Predicted 1-hour concentrations of acrolein are equal to or less than the 2008 OEHHA

REL at all discrete locations where people are known or anticipated to spend time. This suggests that the original HHRA probably overstated the potential short-term (acute) health risks associated with acrolein exposure (as discussed in Volume 3, Section 5.3.3.1 of the EIA). On this basis, the potential health risks associated with short-term inhalation of acrolein are considered low and adverse health effects are not expected at these locations.

References:

Golder (Golder Associates Ltd.). 2005. *Appendix A: Acrolein Monitoring in the Oil Sands Region*. Prepared for: Suncor Energy Inc., Albion Oil Sands Energy Inc. and Imperial Oil Resources Ltd. October 2005.

OEHHA (Office of Environmental Health Hazard Assessment). 2008. *Acute, 8-hour and Chronic Reference Exposure Level (REL) Summary*. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment. Sacramento, CA. Available at: <http://www.oehha.ca.gov/air/allrels.html>.

Request:

- ii. Discuss and address the potential for similar flawed analysis in the HHRA and elsewhere in the EIA.**

Response:

- ii. For the reasons stated in response 89i, it is Shell's view that the HHRA was not "flawed" with respect to its discussion of ambient acrolein concentrations in the Oil Sands Region, nor was it flawed in any other sense. Nonetheless, re-analysis of the acute inhalation assessment for acrolein was completed to reflect revisions to the acute inhalation exposure limit for acrolein used in the HHRA. See response 89i for a discussion of the re-evaluation.

Request:

- iii. Re-assess the significance of this analysis on the Rights of the ACFN.**

Response:

- iii. Shell does not agree with ACFN's contention that the acrolein assessment was flawed.
-

90. Realistic and comprehensive views of individual and community health not addressed.

Request:

- i. Discuss the indirect impacts on the individual and community health of the ACFN from this project and other industrial activities in the region.**

Response:

- i. Shell's HHRA did not assess the indirect impacts on the individual and community health of the ACFN. The HHRA presented in the EIA was designed, in part, to meet the regulatory terms of reference (TOR) issued by AENV for the Project. At this time, Shell does not plan to expand on the HHRA submitted in support of the Project however, Shell is open to discussing how best to assess and to address the health-related concerns of the ACFN as appropriate.

Request:

- ii. Discuss potential mitigations to address these impacts.**

Response:

- ii. Whenever possible, Shell will strive to mitigate the impacts its Project could have on the various determinants of health.
 - Shell is committed to open and continual communication with the ACFN community.
 - Shell's plans to mitigate Project-related impacts were provided in the Socio-Economic Impact Assessment (Volume 5, Section 8.7 of the EIA).

91. Acute inhalation health risks may not be protective of the most sensitive individuals.

Request:

Provide a discussion on the use of the Canada-Wide Standards for particulate matter and ozone in the assessment of health risks from emissions. Consider incorporating CASA's Fine Particulate Matter and Ozone Management tiered Framework, or the World Health Organization's Air Quality Guidelines.

Response:

The Clean Air Alliance (CASA) action triggers for the management of PM_{2.5} and ozone were discussed in the Air Quality Assessment. For the discussion on the PM_{2.5}

management framework, refer to page 3-75, Volume 3, Section 3, and for the ozone management framework refer to page 3-89, Volume 3, Section 3.

For the reasons stated on page 5-30 and 5-31 of the human health risk assessment (HHRA; Volume 3, Section 5), ozone was not included as a chemical of potential concern (COPC) in the HHRA. Ozone was, however, assessed in Section 3.4.5 of the Air Quality Assessment (Section 3, Volume 3). Because ozone was not quantitatively assessed in the HHRA, the emphasis of this response is on the use of the Canada-Wide Standard (CWS) for fine particulate matter (i.e., PM_{2.5}) in the HHRA only.

The selection of the exposure limits employed in the HHRA was described on page 5-64 of the HHRA (Volume 3, Section 5). In order for exposure limits to be included in the HHRA, they needed to be:

- Protective of the health of the general public based on the current scientific understanding of the health effects known to be associated with exposures to the COPC;
- Protective of sensitive individuals through the use of uncertainty factors;
- Established or recommended by reputable scientific or regulatory authorities; and,
- Supported by adequate and available documentation.

The basis of the exposure limits used in the HHRA was further described in Volume 3, Appendix 3-12 (Shell 2007).

Chemicals of potential concern that are regulated at the federal government level in the form of either a National Ambient Air Quality Objective (NAAQO) or as a CWS were not subjected to the same selection process for exposure limits as other COPCs in the HHRA. As such, the federally-regulated CWS for PM_{2.5} was given “priority” over guidelines from other agencies.

The potential health effects associated with exposure to PM_{2.5} were discussed in detail in Appendix 3-12, pages 164 through 172. In this section of the HHRA, Shell states that “the CWS is considered to be an important step towards the long-term goal of reducing the health risks of PM_{2.5}” and that it “represents a balance between the achieving the best health and environmental protection possible and the feasibility and costs of reducing pollutant emissions that contribute to PM_{2.5} in ambient air” (page 169, Appendix 3-12). This section of Appendix 3-12 goes on to describe in detail how the PM_{2.5} exposure limits were selected.

This section also described how predicted 24-hour PM_{2.5} concentrations were compared to the CWS of 30 µg/m³, which falls within the range of recent standards recommended by the World Health Organization (WHO) and the U.S. EPA. Further, predicted annual average concentrations also were compared against the CARB annual standard of 12

$\mu\text{g}/\text{m}^3$, which falls within the range of standards recommended by the WHO and the U.S. EPA. The choice of standards in the middle of the range of available guidelines or standards respects both the need to be conservative and the uncertainty which still remains regarding the types of PM that are most toxic and the existence of a threshold for PM-associated adverse effects.

For the reasons stated, it is Shell's view that the appropriate exposure limits were used for the assessment of PM_{2.5}-related health risks.

References:

Shell (Shell Canada Limited). 2007. *Jackpine Mine Expansion & Pierre River Mine Project Application and Environmental Impact Assessment*. Volumes 1, 2, 3, 4 and 5. Submitted to Alberta Energy and Utilities Board and Alberta Environment, Calgary, Alberta. December 2007.